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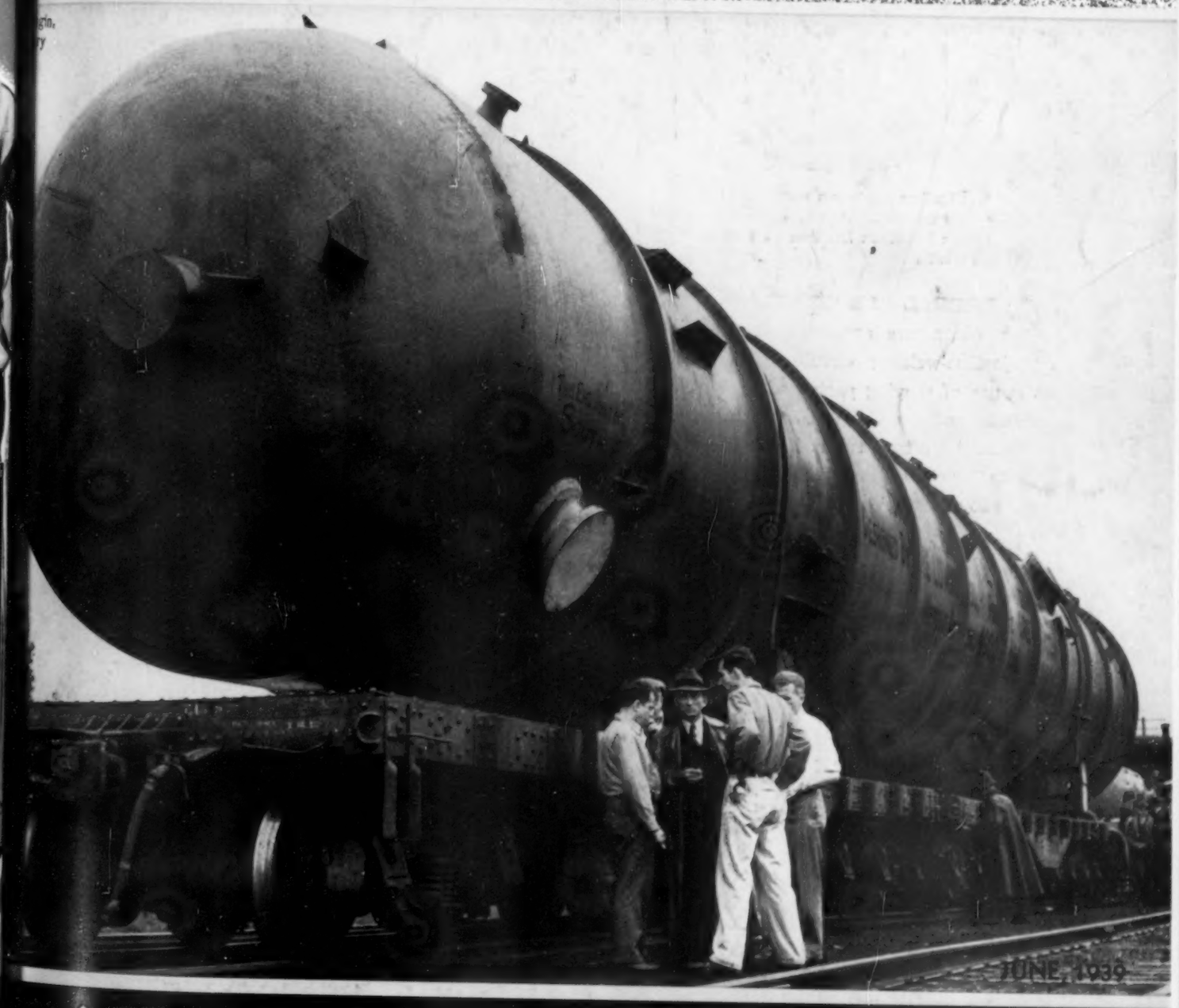
The Welding Journal



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Bubble Tower 13 feet 2 inches x 92 feet 2½ inches thick weighing 490,000 lb. Built by the Combustion Engineering Company.

WELDING RESEARCH SUPPLEMENT

Fundamental Research in Welding 185

ISSUED MONTHLY

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Subscription $5.00 per year in United States and possessions; $5.50 in Canada and Mexico; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents.

Entered as second-class matter January 18, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York, N. Y.

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1—*This cylinder is 4 feet long, 2 feet 6 inches high, with an 18-inch diameter bore and a 24-inch diameter flange face.*

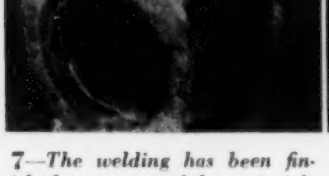
2—*One end of the cylinder was fractured in several places. In preparation for welding, the fractures were veed out.*

3—*The flange face was aligned with a steel bar and heavy clamps. It was pre-heated locally and then bronze-welded.*

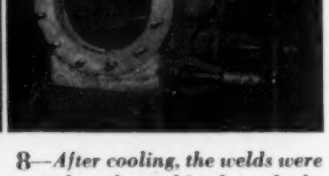
4—*The operator used a standard Oxweld W-17 all-purpose welding blowpipe with goose-neck removable-tip style head.*

5—*About 28 pounds of ¼-inch No. 25 M. bronze welding rod and 2 pounds of Oxweld Brazo flux were used.*

6—*After being welded, the casting was covered with asbestos paper and permitted to cool slowly to prevent cracking.*



7—*The welding has been finished — a successful repair job. The repaired cast iron steam cylinder is as strong as a new one.*



8—*After cooling, the welds were tested and machined, and the cylinder was reassembled on the engine and restored to service.*

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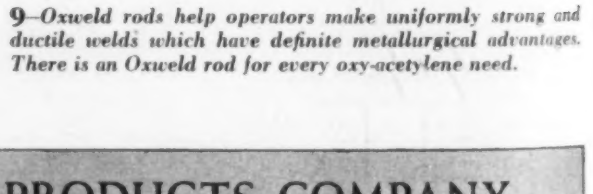

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Welding Journal

VOLUME 18, No. 6 JUNE 1939

SURFACE-HARDENING AND Hard-Surfacing*

By C. E. MacQUIGG†

MAN'S desire to harden metal is older than recorded history and obviously would date from the moment when he found his implements were not equal to the demands of service. This need for hardness in metal may be divided roughly into two main classifications: (*a*) need for hardness throughout—for purposes of greater strength or elasticity of the whole implement or member, and (*b*) need for surface hardness alone. Among metals hardened throughout, we would have, for example, the case of a strong steel needed to transmit stresses or resist deformation. In metals only surfaced-hardened, the chief need is for resistance to wear. Obviously the whole gamut of all uses can be imagined—from the extreme of a simple cantilever supporting a load in space, to that of a solidly supported face plate serving to resist wear. It is the increasing of wear resistance which we propose to discuss here.

Let us first define the two terms which are given as the title of this discussion. Surface-hardening means increasing the hardness of the superficial layers of the *original* metal in place. Hard-surfacing means adding suitable metallic layers *to* the *original* surface.

THREE TYPES OF WEAR

We should confess at once that there is much still unknown regarding the phenomena of wear and the methods of combating it. Wearing of a surface consists of removal of the superficial layers and can be caused by any of the following:

(*a*) Actual detachment of the particles by scraping or cutting action, as in, say, sandblasting.
(*b*) Changing of the nature of the surface by chemical action and removal of the product. This might occur in corrosion.
(*c*) Seizing or galling of the surface in which case the parts in contact may unite in spots as though actually welded.

Almost any combination of these types of wear might be present. Not long ago it was found that in a simple grinding action, the nature of the atmosphere had a marked effect on the wear of the metallic surface. The absence of oxygen materially reduced the wear.

But we may say that in general we get the best resistance to wear with the greatest surface hardness and therefore we strive to attain that property to the maximum extent compatible with the other qualities needed. Hardness is usually measured by resistance to deformation and so our objective methods generally consist of the measurement of the permanent deformation of the metal surface under a given pressure, applied to a carefully standardized implement—as a hardened steel ball or a diamond point. Examples of such test methods are the Brinell, the Rockwell and the Vickers. Still another type of test depends on a quality of resiliency or "springiness" of the surface which in turn is related to "hardness" (elasticity). The Shore Scleroscope is an example of an instrument for making this type of test.

SURFACE HARDENING

This occasion does not demand—nor does time permit—an extensive review of the theory and practice of the hardening and tempering of steel. An important and extensive branch of physical chemistry in itself, its bibliography embraces an imposing part of any technical library. To the specialist it would seem that a start has barely been made here toward mastering the subject.

Just as we all know that a high-carbon steel is intrinsically harder than a low-carbon steel, we also know that metal parts of a given composition can have their *surface* hardness controlled. In increasing the surface hardness we seek as a rule to protect only the surface, because wear is the result of contact between surfaces. Another reason which frequently dictates such practice, is that the harder a material becomes, the less tough or resistant to shock it becomes. Therefore, if we make the surface excessively hard and the inside much softer and tougher, we obtain the ideal combination of simultaneous resistance to wear and to impact.

CONTROLLING SURFACE HARDNESS

We now come to methods for controlling surface hardness. This control may be accomplished by one of the following means:

(*a*) *Varying the Composition During Heat-Treatment.*—For example, increasing the carbon content of the steel surface, followed by suitable heat-treatment, will increase the hardness of the surface. Also metal parts may be impregnated by other metals as in the case of

* Special lecture delivered before the 39th Annual Convention, International Acetylene Association, Houston, Texas, March 8, 9 and 10, 1939.
† Dean, College of Engineering, Ohio State University, Columbus, Ohio.

steels surface-treated at high temperatures to absorb chromium.

(*b*) *Treatment by Heat Without Varying the Composition.*—Alloys of given composition may have their hardness varied by heat treatment without changing the composition. In general, steel and many other alloys such as the bronzes, brasses and aluminum alloys, are solutions and mixtures of considerable but variable complexity. The carbon in the steel seeks to form carbides and some of the other elements tend to form compounds. These may be thought of as existing in various degrees of solution. The heat-treatment and tempering steps, therefore, control the *solubility* and *aggregation* of these compounds which in turn determine the physical properties of the metal. Thus a steel, for example, may be given an amazing range of mechanical properties when we have actually neither added to nor taken from its composition.

(*c*) *Cold Working.*—Cold working metal up to a critical degree will also produce hardness but this may be attended by non-desirable features.

Table 1—Surface-Hardening Processes

1. Hardening by Cementation
   - (*a*) Carburizing
   - (*b*) Nitriding
   - (*c*) Cyaniding
2. Hardening by Heating and Quenching
   - (*a*) Furnace-Hardening
   - (*b*) Electrical-Hardening
     - (*i*) Direct Heating
     - (*ii*) Induced Heating
   - (*c*) Flame-Hardening

From this brief summary we can outline the methods most commonly used for producing high surface hardness (see Table 1).

SELECTING THE HARDENING PROCESS

In selecting the method to be used for producing surface-hardness, there are so many factors to be taken into consideration that experience becomes the most reliable guide to follow. This is especially true since we have no generally accepted laboratory types of test which will be equally applicable to all conditions of service. In adopting a method for surface hardening, we must not sacrifice other desirable qualities in our hardened product. We must not sacrifice the over-all or integrated toughness of the hardened article, else we will lose by increased breakage of the surface or even the whole implement. We must avoid cracking of the surface during or subsequent to hardening.

There are certain factors to be considered in selecting any one of the methods for surface hardening, or, for that matter, any hardening method including hard-facing. They may all be resolved into:

Fig. 1—Flame-Hardening Is the Only Practicable Method for Hardening the Wobbler Pads of This 9-Ton Spindle

(*a*) Cost
(*b*) Convenience
(*c*) Serviceability

Cost.—The primary objective of any hardening process is, of course, to increase the life of the part. If at an increased cost of, say, 50 per cent the life of the part can be increased 300 per cent, it is obvious that hardening will effect substantial savings in terms of reduced replacements. When the hardening cost is equal to or greater than the savings in replacement costs the problem becomes more complex. As an example, suppose that a part, which costs a dollar and normally lasts a month, is hardened at an additional cost of a dollar and now lasts two months. At first glance, the cost of hardening does not seem justified. However, an increase in life results not only in fewer replacements, but in fewer shut-downs as well. Thus a reduction in down-time for a machine means a reduction in losses arising from idle labor during the replacement. This means an increase in production and efficiency. As a typical example, hard-faced grinder rings used in cement mills last, with occasional slight repairs, from 10 to 18 times as long as plain steel rings. Even if a hard-faced ring cost more than 10 plain steel rings, its use would still be justified, since the elimination of nine replacements saves about 100 hrs. in otherwise lost production time.

Convenience.—This is a factor which, after all, is reflected in cost, especially when considering easy and instant applicability to the job. Convenience in method means that frequently elaborate installations may be avoided. More particularly, the ease and speed with which the method may be applied to *the work in place* may spell the difference between success and failure (Fig. 1).

Serviceability.—This factor also is made up of several elements. The satisfactory behavior of parts already tested is the surest criterion. Long life alone is not the only factor, since a report on this subject states:

"Another important factor which has a direct bearing

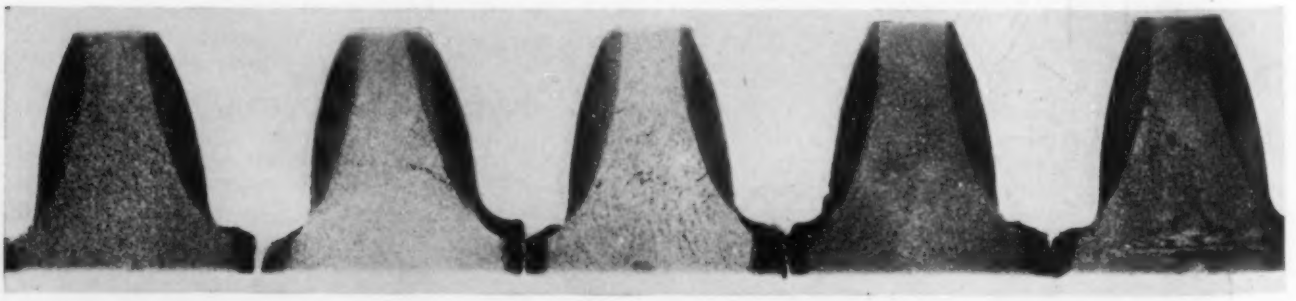

Fig. 2—Showing the Uniformity of the Case of Five Polished and Etched Cross Sections of the Same Gear Tooth

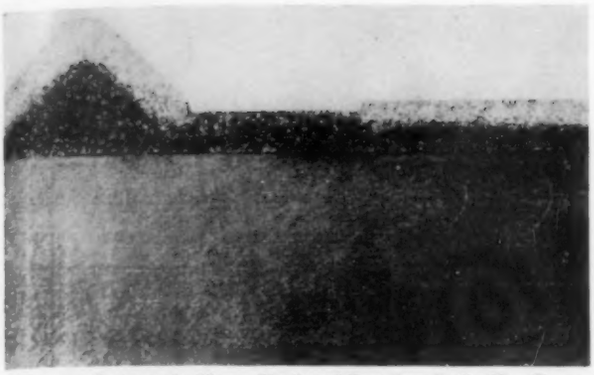

Fig. 3—Cross Section of a Flame-Hardened Cast-Iron Lathe Way Showing the Depth of Hardness (Approximately 1/8 Inch) and Close Grain Structure

on cost, but which is difficult to evaluate accurately, is the increased efficiency of the wear-resistance surface. Often, parts which wear rapidly affect the rate of production and lower the efficiency of the machine. Referring again to cement grinder rings, records show that the output of a hard-faced ring remains almost constant throughout its life, whereas with a plain steel ring, the output drops as the ring wears until, when the ring is ready for replacement, it is only 70 per cent efficient. The average increase in production made possible by hard-facing these rings is estimated to be from 15 to 20 per cent."

Since we are first concerned here with the flame-hardening process, let us assume that after having considered the various factors involved, we have selected flame-hardening as the method to be employed.

FLAME-HARDENING

Flame-hardening may be defined as a process whereby the surface of a quench-hardening ferrous material is locally heated by means of an oxyacetylene flame followed by a suitable quench. In other words, the surface of the part to be hardened is rapidly raised to the required temperature with the intense heat of the oxyacetylene flame and then very rapidly cooled, usually by a stream of water.

ADVANTAGES OF FLAME-HARDENING

From a metallurgical viewpoint, flame-hardening has an advantage in that no change of chemical composition takes place in the hardened surface. Flexibility is also an adjunct of this method, since only the portions of the surface which require hardening need to be so affected (Fig. 2).

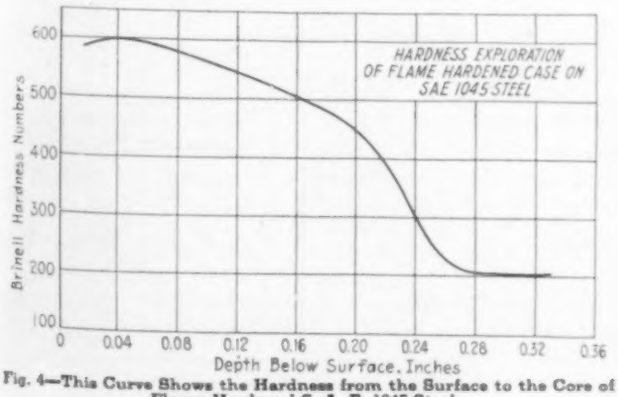

Fig. 4—This Curve Shows the Hardness from the Surface to the Core of Flame-Hardened S. A. E. 1045 Steel

Effective Quenching.—The process is thus seen to be extremely simple and merely that which is followed in all heating and quenching operations. There is this important difference however; with flame-hardening only the superficial layer of metal is heated to the hardening temperature and an additional quenching action is derived from the relatively cold mass of metal lying below the heated surface. This underlying metal, because of its vastly superior heat conductivity over that of ordinary quenching media, subtracts the heat from the superficial layers and thus produces a more drastic quenching action than would result from the liquid alone. This can be taken advantage of in producing initially harder surfaces than could be obtained with the conventional method of heating the mass of metal to the center and then abstracting all of the heat through the surface in the conventional quenching bath. With some conditions it is possible to dispense entirely with quenching. It will be apparent that flame-hardening presents advantages in the way of making possible the heat-treatment of spots or restricted areas.

Speed of Operation.—In many shops, highly specialized methods of heat-treatment with specially designed furnaces have been developed for differentially hardening a variety of machine parts. While these have been and will continue to be very successfully used, there are

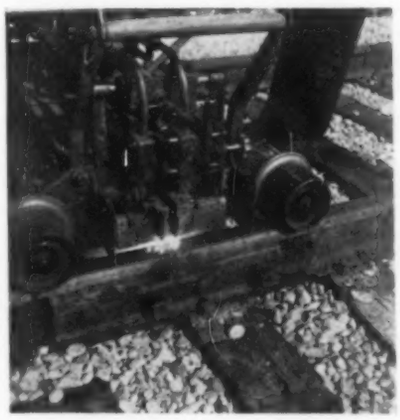

Fig. 5—Rail Ends Are Now Hardened by Means of Automatic Machines

many places where flame-hardening can replace these methods. The speed of heating in these special furnaces is slow as compared with the oxyacetylene blowpipe with the result that the heat, and consequently the hardness, penetrate to too great a depth. This often necessitates a sacrifice in surface hardness in order that the body or core of the piece will retain the desired properties.

Good Case Characteristics.—Partly because there is no transformation with accompanying volume change of the core of the flame-hardened steel, the stresses between the hard surface and the relatively ductile core are low and this makes for the freedom from spalling or "shelling out," which must be avoided in some other methods of surface-hardening. The depth of hardness and case may be varied by the heating rate and time the composition of the steel being used, the time of heating and the quenching practice used. The case generally lies between 1/16 and 1/4 inch in depth, while hardness is at least equal to that resulting in the same steel from furnace-hardening (Fig. 3). Assume, for example, that in order to obtain certain core properties, a steel is selected which is capable of being hardened to a Brinell hardness number of 600. If the desired surface hardness is 400 Brinell, the quenching or application of the coolant may be interrupted some time after transformation has started so

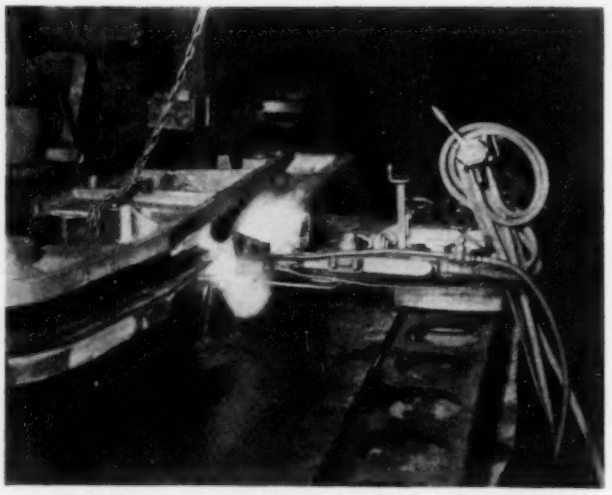

Fig. 6—This Work on Conveyor Rails Is a Typical Progressive Flame-Hardening Operation

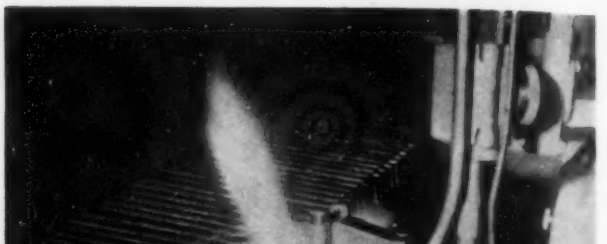

Fig. 7—The Quenching Spray for This Pipe Wrench Hardening Operation Is Attached to the 30-Flame Heating Head

that a lower order of hardness can be attained. Similar results are often obtainable through the use of a mild quench, but it is not always convenient to employ a quench other than water. The point here is that the process is extremely flexible and can be varied to produce the desired results or to conform with immediate conditions.

Thin Sections Treated.—The speed of heating by the oxyacetylene flame makes possible the surface hardening of sections as thin as 1/4 inch, and even thinner, with proper technique. This cannot be done by most other methods because the requisite temperature gradient is not attained.

Scale-Free Surfaces.—Because the part is so quickly raised above the critical point and then promptly quenched, flame-hardened parts are scale-free. Distortion depends on the thickness of the material and the depth of hardening, so great care must be exercised in hardening thin sections. Thick sections present no problem because the core is but slightly heated and the surface contour is preserved. Generally speaking, distortion is well within manufacturing tolerance.

APPLICATIONS OF FLAME-HARDENING

Due to the fact that flame-hardening is adaptable to complicated parts with less danger of distortion or other faults, it is used for the treatment of rail ends, pump liners, crane wheels, gears, tractor shoes, sheave wheels, machine ways, valves, crank and cam shafts and many other parts. The portability of the equipment used for flame-hardening makes for the convenience already mentioned. The hardness-depth relationship is seen in Fig. 4.

Flame-hardening of rail ends was taken up extensively in this country about 1928, and since this date some 5000 miles of track have been treated. Machines facilitate this treatment in place (Fig. 5) also much new rail is flame-hardened at the mills. It would be hard to conceive of a more convincing shock test or fatigue test than that administered by the pounding drive wheels of an express train at high speed, and the service performance of the hardened rail ends is indicative of the high shock-resistance and fatigue-resistance of flame-hardened surfaces. Oil field applications include those for ball races for rotary tables and for the universal joints of mud hose, draw works, gear teeth, sucker rods and box and pin ends of drill pipe.

However, flame-hardening should not be considered a universal tool adaptable to all types that require surface hardening. Like any other process, it has certain limitations. For instance, it may be more economical to batch-harden a large number of small parts by means of case carburizing or nitriding. It might well be stated here that flame-hardening, as such, is not just a matter of purchasing the required hardening equipment, but should be thoroughly investigated before being adopted for operations formerly performed by other heat-treating methods.

Table 2—Flame-Hardening Steels

Flame-Hardening Steels	*Type Analysis*	**Case Hardness*	
		Scleroscope	*Brinell*
S.A.E. 1035-1070	C-.30-.80, Mn-.70 max.	50-90	350-700
S.A.E. T1335-T1345	C-.30-.50, Mn-1.60-1.90	75-90	550-700
S.A.E. 2340-2350	C-.35-.55, Ni-3.25-3.75	70-80	500-600
S.A.E. 4140-4150	C-.35-.55, Cr-.80-1.10, Mo-.15-.25	70-85	500-650
S.A.E. 4640	C-.35-.45, Ni-1.65-2.00, Mo-.20-.30	70-80	500-600
S.A.E. 5140-5150	C-.35-.55, Cr-.80-1.10	70-85	500-650
S.A.E. 6135-6150	C-.30-.55, Cr-.80-1.10, V-.15-.20	75-85	550-650
Carbon-Vanadium	C-.45-.65, V-.15 min.	70-90	500-700
Cromansil	C-.30-.45, Cr-.40-.60, Mn-1.00-1.30, Si-.70-.90	75-85	550-650
Manganese-Molybdenum	S.A.E. T1335 or T1340 plus Mo-.15-.25	75-85	550-650

*Hardness determinations on flame-hardened parts should preferably be made with the scleroscope. The Brinell numbers shown here have been converted. Hardness figures are for water-quenched materials.

FLAME-HARDENING STEELS

In selecting a suitable steel for flame-hardening, we may say that: (*i*) plain carbon steels can be hardened satisfactorily provided the carbon is more than 0.40 per cent. The upper limit of carbon is dependent upon the method of hardening used, but it is generally safe up to 0.70 per cent carbon or higher depending on the section; (*ii*) Alloyed steels are satisfactory through a wide range of compositions, but in general because of economics this class of steel is restricted to the low or medium alloy types, i.e., in which the percentage of the principal added elements is low.

The accompanying Table 2 shows some of the steels which have been successfully used.

FLAME-HARDENING METHODS

Heating.—In practice the operations of flame-hardening may be classified as (*a*) stationary, (*b*) progressive and (*c*) spinning. In the stationary procedure, the blowpipe and the work are both motionless during the operation. This is sometimes called "spot-hardening."

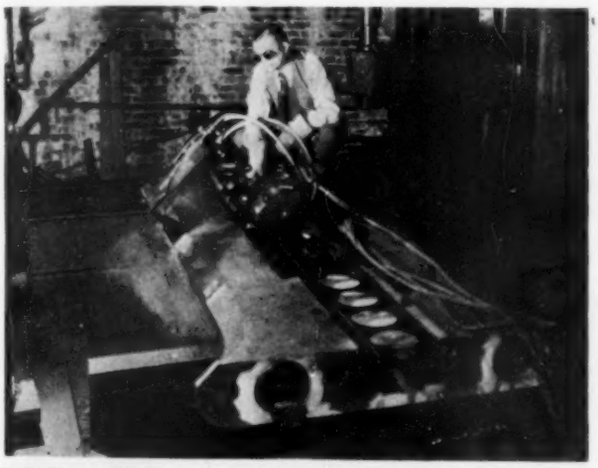

Fig. 8—Flame-Hardening the Ways of a Hydraulic Press by Means of the Progressive Method

Surprisingly good results are obtained by the hand flame-hardening. As an introduction to the simplicity and effectiveness of the process, a trial can be made by locally hardening a small scrap piece of medium-carbon steel. It is only necessary to heat a small area of the surface with a welding blowpipe or with the preheating flames of a cutting blowpipe and then quench with water. The increase in hardness can be tested easily with a file. A number of shops throughout the country use this method to flame-harden a great variety of articles.

In the progressive method, the flame and the work are moved relatively to each other, and the metal is quenched as it is brought up to temperature by the moving blowpipe. For flame-hardening a plane surface, the lighted blowpipe, with a head producing sufficient flame area to cover the path to be hardened, is directed along the surface at the maximum speed which will heat the surface zone to above the critical point of the steel. Immediately behind the flame is a stream or spray of water which progressively quenches the heated surface. Speed is determined by operating variables such as flame intensity, type of steel being treated and the temperature desired. It may vary from 4 to 10 inches per min. although the usual speed is from 6 to 8 inches per min. Figures 6, 7, 8 and 9 illustrate typical progressive hardening applications.

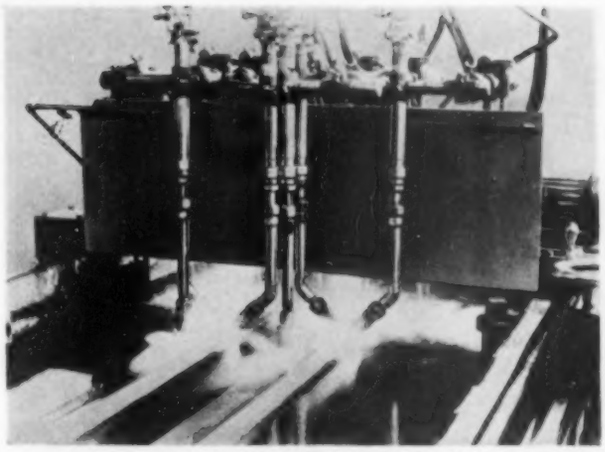

Fig. 9—Six Heating Heads in Place of the Three Shown Are Now Used to Flame-Harden the Cast-Iron Ways and Vees of This Lathe Bed

In the spinning method, which is applied principally to rounds, the blowpipe is stationary and the work is rotated before the flames. When the entire area has reached hardening temperature, the quench is applied while the work is still rotating. The time for hardening by this method will vary from a few seconds to 2 or 3 min. The application shown in Fig. 10 is illustrative of the spinning method, as well as of the combination method in which the heating head traverses the work from one end to the other as the work is rotated.

Quenching.—Quenching attachments are usually affixed to the heating head for progressive hardening, thus insuring a constant relation between heating and quenching. Many devices may be used, ranging from a simple stream of water from a round nozzle to a carefully designed spray nozzle. Spinning operations are better controlled by quenching with a large volume of water under low head. This simulates total immersion.

Certain steels are too sensitive to be quenched with

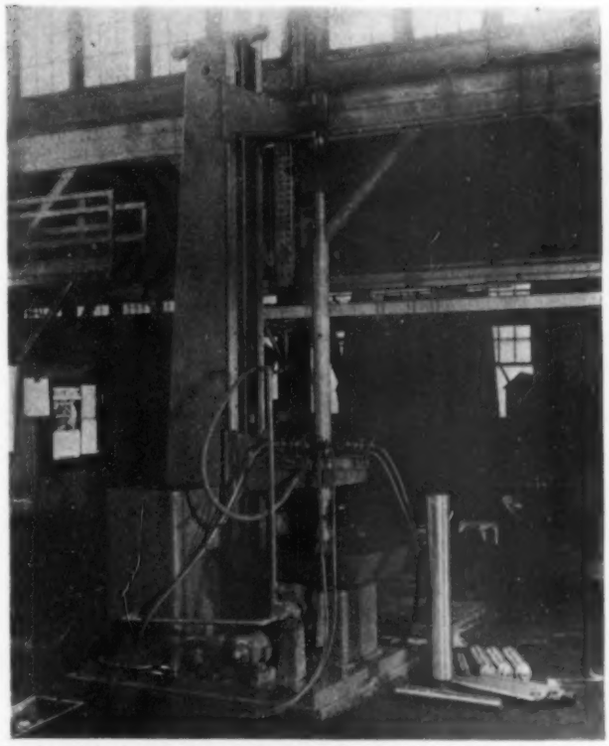

Fig. 10—Cylindrical Objects, Such as Shafts, Are Ideally Hardened by Means of This Efficient Set-Up

Fig. 11—Hard-Facing Alfalfa Mill Hammers with Cobalt-Chromium-Tungsten Rod

water. It has been found that a milder quench is obtainable by using soap-water solutions or a soluble cutting oil in water. If machine tools are used for flame-hardening, the cutting-oil systems can be used for quenching.

Drawing.—As a rule, flame-hardening operations should be immediately followed by a low-temperature draw to relieve quenching stresses. This can conveniently be done in an oil bath or oven. However, while generally recommended, the drawing operation is not always necessary, since, by carefully controlling the quantity and application of the quenching medium, or delaying its application, the hardening treatment may be made self-drawing.

HARD-SURFACING

Hard-surfacing or "hard-facing," a process of comparatively recent development, consists in welding on to wearing parts a facing, edge or point of a hard metal, exceptionally resistant to abrasion. By this method, metal surfaces which normally wear away rapidly in service are protected by a layer of special alloy possessing unusual wear resistance. To meet adequately the various requirements of hardness, toughness, shock resistance and other qualities, various hard-facing alloys of widely different compositions have been developed.

Fig. 12—Applying Hard-Facing Rod to the Cutting Surfaces of an Oil Well Drilling Bit

Broadly speaking, however, these may be divided into four groups: (1) Low-alloy steels, (2) high-alloy steels, (3) non-ferrous alloys and (4) tungsten carbides and borides.

Group 1.—For the first group there is no sharp definition of composition. If the alloying constituents are less than approximately 5 per cent, it would be accepted as low-alloy steel in connection with hard-surfacing. While not as wear resistant as the other groups about to be described, it has some advantage in toughness and shock resistance. Manganese, chromium, molybdenum, vanadium and tungsten are the most commonly used alloying elements, generally with carbon about 0.3 to 0.6 per cent.

Group 2.—If the alloying elements are present in excess of approximately 10 per cent, the hard-facing material falls in the second group. These steels almost invariably contain high-chromium for extra wear resistance. Manganese, cobalt, tungsten and nickel may also be present in this group. Somewhat more expensive than the low-alloy types, this group is notable for markedly greater wear resistance than the low-alloy group. Due to longer life of these metals, they frequently are more economical in the long run than the less expensive metals.

Group 3.—Non-ferrous alloys of cobalt, chromium and tungsten are included in the third group. They are available in several different grades, all highly resistant to wear, but having a spread in strength and toughness which makes them suitable for a wide range of hard-facing applications. Because of their non-ferrous composition, these alloys have the unique property of red

Fig. 13—Applying Hard-Facing Alloy to the Seating Surface of a 9 Inch Diameter Valve Disk

hardness, that is, they retain their original hardness practically unimpaired at elevated temperatures (Fig. 11).

Group 4.—The fourth group consists of the so-called diamond substitutes, the hardest and most wear-resistant of all hard-facing materials. Some of these are almost pure fused tungsten carbides, while others contain 90 to 95 per cent tungsten carbide, the remainder usually being cobalt, nickel or iron. These diamond substitutes are furnished in the form of small castings, known as inserts, and in the form of welding rods in which the hard particles are packed in steel tubes. The tungsten carbide inserts are welded and imbedded into the wearing surfaces of oil well drilling bits and similar tools by means of other metals (Fig. 12). Because of their extreme refractoriness, these compounds are not melted or otherwise greatly affected by the oxyacetylene flame; they are "wetted" by the molten metals and thus become fused in place—much as a lump of tinned steel might be soldered to a piece of copper. Thus, they are held in place without difficulty on the wear-resisting surface.

SELECTING THE HARD-FACING ALLOY

In order to select intelligently the correct hard-facing material for any particular application, it is necessary to determine those factors which cause the deterioration of the wearing part. Thus, if there is an element of corrosion involved, the material may differ essentially from one which might have to resist shock alone. Again, the nature of the surface must be taken into account. Must it be smooth—or will roughness (as in a cutting surface) be advantageous? Finally, cost must always be considered, although first cost may be subordinated to length of life. Table 3 is an effort to depict the groups with relation to their chief attributes. Obviously no such representation can be made wholly rigid, but it will be suggestive of the main criteria one should have in view when selecting material for a given application.

Table 3—Guide to Selection of Hard-Facing Alloy

Group 1—Low-Alloy Steels
Group 2—High-Alloy Steels
Group 3—Non-Ferrous Alloys
Group 4—Tungsten Carbides

Characteristic of Deposit	Group Number
Cold Hardness	4 2 3 1
Red Hardness	4 3 2 1
Resistance to Impact	1 2 3 4
Corrosion Resistance	3 2 1 4
Smoothness of Deposit	3 1 2 4
Ability to Scour	4 2 3 1
Thinness of Welding	3 2 1 4

Three examples will serve to illustrate the use of this table Mining equipment used for crushing rock and ore is subjected to constant battering and impact. Here resistance to shock and impact is all-important, with hardness only a secondary consideration. This should indicate a preference for hard-facing alloys of Groups 1 or 2. In practice, these materials have proved to be the most suitable for this type of service.

Valves for handling high-temperature, high-pressure steam, gas, oil and acids must resist heat, erosion and corrosion. It has been found that alloys of Group 3 work extremely well for the seating surfaces of these valves because of their red hardness and corrosion resistance.

No matter how ideal their other properties, alloys of Group 4 would not be suitable for this service because of the extreme roughness of their deposits. However, the very nature of the rough deposits of the Group 4 alloys results in an extremely efficient digging edge. This factor, together with the greater hardness of these materials, is the reason for their widespread use on oil well drilling tools, dredge cutter blades and other parts coming in contact with earth, sand and gravel.

Fig. 14—This Plowshare, Hard-Faced Only in Spots, Plowed 15 Acres of Sandy Soil. Note How the Balance of the Share Has Worn Away

Fig. 15—This Hard-Faced Exhaust Valve Seat Insert Will Not Require Regrinding or Refinishing After a Run of 150,000 Miles or More

HARD-FACING PROCEDURES

While any of the standard methods of fusion welding may be applied to hard-surfacing, as members of this group you are interested in the special advantages of the oxyacetylene process. In the first place, the blowpipe allows a close control of the operation and results in a smooth deposit. Particles of scale and foreign matter may be floated out. Ease of control permits the building of edges and corners, thus facilitating subsequent grinding to close tolerances. The blowpipe seems to facilitate manipulation of those hard-facing materials which must be "puddled in" to the surface—as well as those which are "sweated" onto the surface; flexibility of the heating flame permits either set of conditions. Finally, the technique is not difficult and may be learned quickly by any proficient welder.

MATERIALS WHICH MAY BE HARD-FACED

With regard to the kind of materials which may be surfaced, all plain carbon and low-alloy steels may be so processed, provided the carbon content is not substantially in excess of 0.5 per cent carbon. Higher carbon

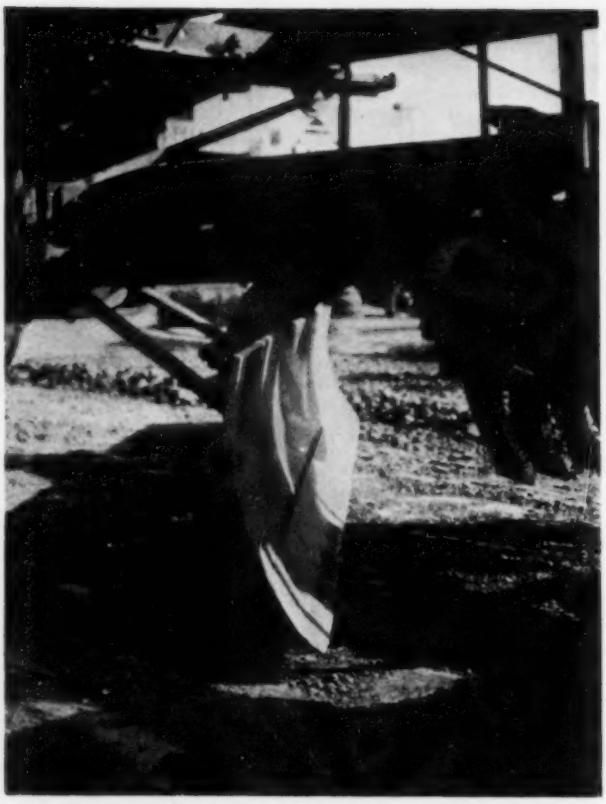

Fig. 16—Hard-Faced Road Grader Blades Develop a Self-Sharpening Action Which Greatly Prolongs Their Life

and alloy contents require, under some circumstances, special heat treatments subsequent to the operation of surfacing, and preheating of the part to be surfaced may be required. Gray cast iron and alloy cast irons are readily hard-surfaced. On the other hand, brass, copper or bronzes cannot be hard-surfaced because of their relatively low melting points. Only a few typical hard-surfacing applications will be mentioned.

HARD-FACING APPLICATIONS

In the oil industry, it is interesting to trace the parallel development of the hard-facing process and oil well drilling tools—tools of more intricate design and made of better materials. It is a long step from the shop-dressed and tempered fishtail bit to the latest type of cast or forged bits having multiple cutting and reaming blades. Such intricate tools as are available today would probably never have been feasible without the extra long life imparted to them by hard-facing materials. As an example—in passing—of the benefits derived, it has been possible to cut drill consumption in certain East Texas wells, from 84 to 14 bits. In soft formations as much as 2000 feet per bit is not an unusual record, and even in considerably harder formations, bits faced with diamond substitutes may average 600 to 700 feet. The use of hard-facing in the oil and gas industry is not, however, confined to rotary bits. Pump shafts, pump runners, shaft sleeves, catheads, side-tracking mills, core heads, go-devils and refinery valve seating surfaces all may be economically protected by hard-facing.

Just a brief word should be said about these refinery valves (Fig. 13). During the past few years there has been a definite trend toward the use of hard-faced seating surfaces for valves where operating conditions are such as to demand that seat and disk material be free from seizing and galling, and at the same time be corrosion resistant. Hard-faced valves have proved particularly dependable for handling high-temperature, high-pressure steam, as well as for handling hot, high-sulphur crudes containing free SO_2 and SO_3. These valves are free from scoring and wire-drawing, remain tight and insure leak-proof dependable performance.

The agricultural industry was one of the first to adopt hard-facing (Fig. 14). Plowshares not only last 3 to 7 times longer when hard-faced, but also require less sharpening and maintain a cleaner cutting edge. Tests carried out by several State University Agricultural Experiment Stations have definitely proved that plowshare costs are reduced by at least one-half by hard-facing.

The automotive industry, a pioneer in many metallurgical improvements, has adopted hard-facing for not only its manufacturing machinery, but also for wearing parts of bus and truck motors (Fig. 15). Probably the most outstanding example of the use of hard-facing material in the automotive field is for armoring exhaust valve seats. Most of the manufacturers of heavy-duty trucks and buses have standardized on hard-faced exhaust valve seat inserts, because these seats last longer, require less attention and reduce valve grinding and adjustment to a minimum. Other advantages are lower gasoline consumption, lower compression losses, and increased power, mileage and all-round motor efficiency.

One of the most extensive uses of hard-facing is for protecting the teeth of dipper buckets, dragline buckets, clamshell buckets and ditching machines. The wear on equipment designed to handle rock, sand and gravel is so terrific that it is only natural to expect the use of hard-facing materials for the wearing parts. Hardly a single piece of machinery used in the building and maintenance of roads will not operate more efficiently and economically when hard-faced. Road scraper blades (Fig. 16), sub-grader blades, scarifier teeth, plows, tractor treads, crushing machinery and tar scrapers for the seams of concrete roads are all hard-faced with very successful results.

In other industries, hard-facing applications are just as many and just as varied. Brick dies, cement grinder rings, coke pusher shoes, steel mill shear blades, lumber mill shredder knives and coal undercutter bits are typical of the variety of parts which are economically hard-faced.

In conclusion it has been possible only to "high spot" the essential features of flame-hardening and hard-surfacing. In spite of rapid acceptance of these new aids to protection and efficiency, it is reasonable to predict that only a start has been made. Just as corrosion-resisting steels have opened entirely new possibilities in our modern technology, so also will these new means of combating wear prove equally epoch-making.

1938 Bound Volume Journal

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TELEPHONE BUILDING—East 37th Street Section "D"—No. 864*

By R. A. BACKUS†

WELDING, now permitted under the new Building Code, was at once considered for the structural design of this project for three reasons. First, it would undoubtedly be cheaper for an addition of this kind; second, it would be less objectionable from a noise and nuisance standpoint; and third, it was a proved practical and safe method of making structural connections when properly supervised.

COST

We believed the saving in cost would be confined to field work only, so prepared the structural design for shop riveted and field welded connections. The field connections referred to are the connections of new steel to existing steel and such connections which would otherwise be riveted; viz. column splices and all connections to columns and within 3 feet 0 inch of columns. The general framing of new beams to new girders were to be bolted in any case.

To get comparisons in steel cost, prices were obtained for the following combinations:

Base Bid	Shop riveted and field welded.
Alternate No. 1	Shop and field welded.
Alternate No. 2	Shop riveted and field connections with turned bolts.
Alternate No. 3	Shop and field riveted.

Prices were obtained from seven bidders. Comparison with base bids were as follows:

Alternate No. 1 was 98.5%	(Lowest bids compared)
Alternate No. 1 was 100.3%	(Average bids compared)
Alternate No. 2 was 104.6%	(Lowest bids compared)
Alternate No. 2 was 102.1%	(Average bids compared)
Alternate No. 3 was 101.2%	(Lowest bids compared)
Alternate No. 3 was 102.4%	(Average bids compared)

The average of the bids on Alternate No. 1 was 100.3% of the average of the base bids. This confirmed our original belief that savings would be shown only by field welding. It happened, however, that the low-bidder on Alternate No. 1 was the low-bidder on the Base Bid. He figured the same unit price per ton (about $100), but figured he could save six tons of material in shop connections which brought his Base Bid from $40,500 to $39,900 for Alternate No. 1, a saving of $600 or 1½%. This saving should be added to the difference between the low base bid and the low on Alternate No. 3 (shop and field riveted) of $500, making a total of $1100 saving in steel contract price when comparing the welded with riveted method.

The steel saving, however, was but a small part of the total saving. As this project was on a cost plus basis, we cannot know exactly what saving was made in the general work by the use of welded connections. But we can review certain work as actually done and compare it with what would have been done without the use of welding.

There was a total of about 125 connections of new steel beams to the present steel work. With welded connections, holes only large enough to admit the new section, had to be cut into the brickwork or fireproof covering of old steel to permit the welded connection to be made to webs of present beams or columns. If these connections had been made with bolts or rivets, the floor construction in the old building would have been cut away sufficiently to allow drilling new holes in the old steel and for installing bolts or rivets. About 55 of these connections were to the web of the outer of double beams which would have meant added difficulties for bolted connections.

In addition to the cost of this cutting and later patching, it would have been necessary to install dust proof partitions at once. The easterly wall of the front wing of the old building was left standing until a recent date, thus leaving this portion of the old building undisturbed for a long period. In the fourth story, an important switchboard between columns 10 and 15 had to be kept in operation near, and anchored to, the old wall between these columns. Had the floor construction under this switchboard (or over the switchboard) been cut out to provide bolted connections for the new beams, there would probably have been a serious interruption of the service. It is hard to put a price on the saving here due to welding.

Disregarding the possible saving in the reinforcing of certain present columns and girders, we might roughly estimate the saving in welded connections in this way. Assuming each welded connection of new beam to old steel at about one-half the cost of drilling and bolting, a saving of say $5.00 and the saving in general work of protection, cutting and patching at about $15 per connection, we would figure about 125 × $20 or $2500 which, with the steel saving of $1100 is a general saving of $3600. We might add a saving of say $400 as a nuisance value of early and more extensive dust-proof partitions required with bolted and riveted connections.

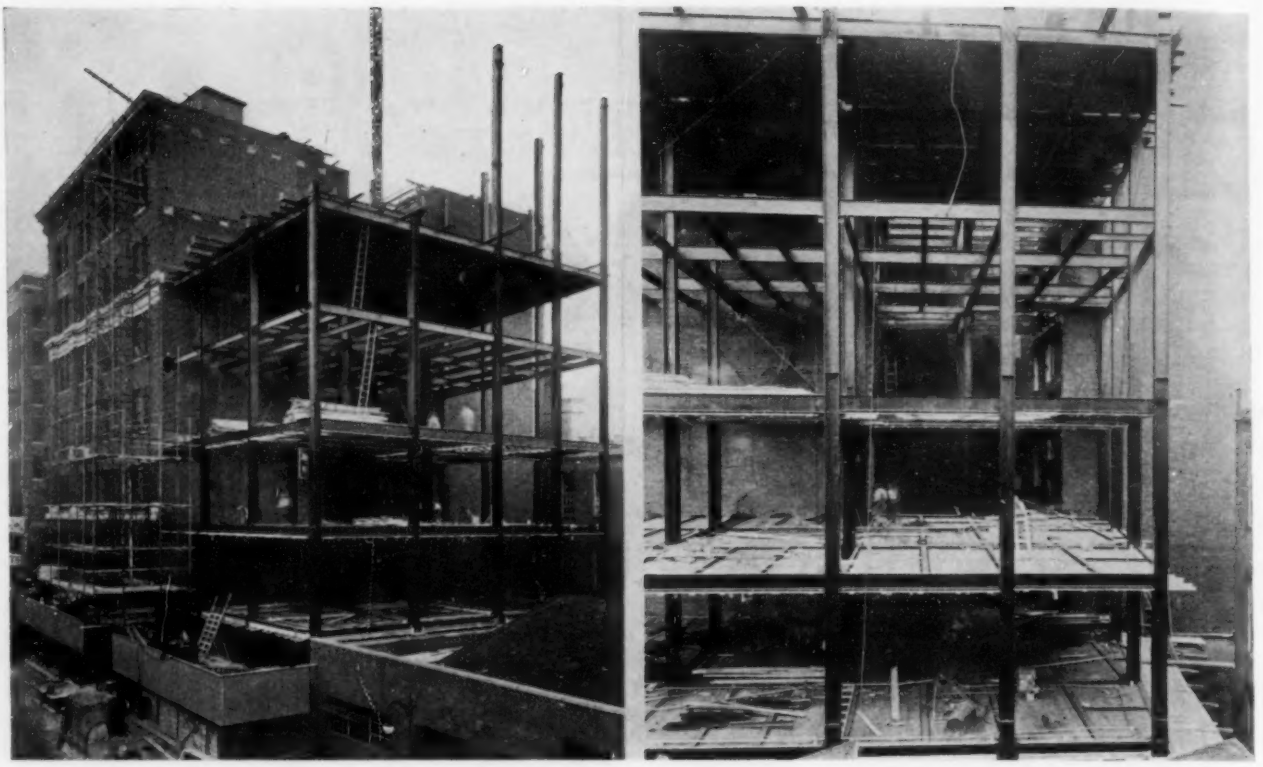
From this total of $4000 we should deduct the increased cost of testing and inspection for welded work. This amounted to about fifty (50) cents per ton or $200, leaving a net saving of around $3800. This, we believe, is a minimum.

In the matter of the cost of "extras" caused by revisions or additions to the steel work, there is no material difference between welded and riveted work.

NOISE AND NUISANCE

From a noise standpoint, welding avoided the noise of the pneumatic hammers in driving from 1500 to 1800 rivets. This would have been particularly objectionable

* Visited on an inspection trip by New York Section, A.W.S.
† Voorhees, Walker, Foley & Smith.



Views of the Addition to the Telephone Building at East 37th Street. These Photographs Also Show the Comparatively Simple Connection of the New Addition to the Old Building

in the maintenance of telephone service. However, the other noises of erection were all present—the unloading, hoisting and setting with the accompanying bell ringing and shouting—and were, of course, objectionable, but unavoidable.

Welding, from a nuisance standpoint, was important primarily for the considerable saving in cutting of the existing construction with its attendant noise and dust.

SAFETY

Welding, as a structural process, has undergone a consistant and thorough development during the past 20 years and more. After thousands of tests, etc., the theory of welding is firmly fixed. It has been accepted by most of the large cities of the country and it has been used in hundreds of buildings.

It is, however, a process which depends to a large extent on the "human factor." For this reason it is imperative that proper and experienced supervision and inspection be employed. This is not only for the Owner's protection but it is also required by the Building Code.

It is a matter of interest as well as satisfaction that this is the first commercial building erected in New York City where arc-welded connections were used in shop and field.

Redesigning for Welding

By K. R. SHEPARD*

ALL-WELDED ALUMINUM WINDOW SASHES ARE MADE WITH IMPORTANT SAVINGS

THE saving which results when metal products are designed specifically for welded construction is well illustrated by the experience of one manufacturer who was faced recently with a difficult problem in the production of aluminum window sashes.

This concern, which manufactures a wide variety of window frames for railroad cars, street cars, buses and subways, received an order for 3400 aluminum sashes for subway car windows. Specifications called for the inside corners of the sashes to be rounded, and, after some preliminary tests, the design shown in Fig. 1 was decided upon.

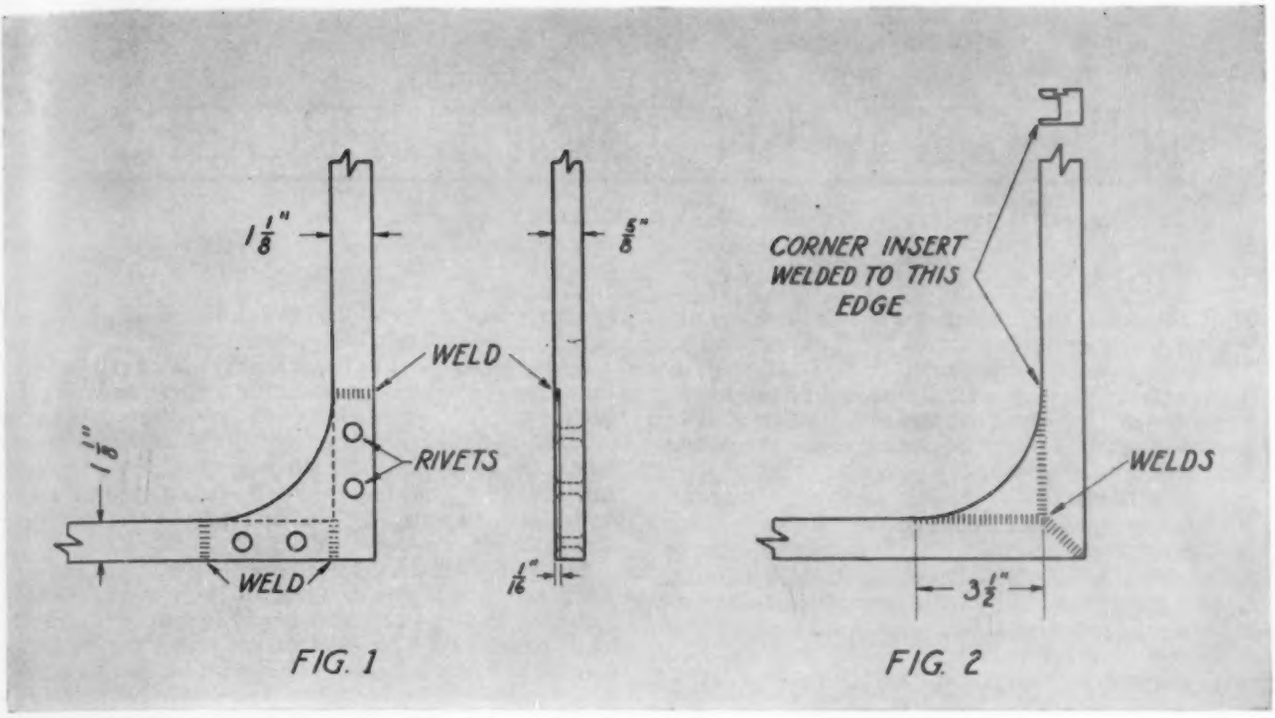
Preliminary Design

As indicated by the sketch, this design called for a combination of welded and riveted construction. The vertical and horizontal rail members were joined together by the weld nearest the corner, while the rounded insert was attached to these members by means of four rivets—two to each rail. The primary purpose of the two welds joining the ends of the insert to the rails was not to provide strength, but to make the junction between the insert and rails invisible. In addition to the three welding operations, fabrication of this corner also required a milling, drilling and double-riveting operation.

All-Welded Construction

After several test sashes had been made up using this type of design, it was felt that the corner construction could be simplified considerably by redesigning for all-

*The Linde Air Products Company.



Redesign of the Riveted and Welded Corner (Fig. 1) to the All-Welded Construction (Fig. 2) Resulted in Speeding the Fabrication of Aluminum Window Sashes

Fig. 3—All-Welded Window Sashes Are Turned Out at the Rate of 5 to 5½ Per Hr. with the Aid of This Ingenious Jig

welded fabrication. This proved to be the case when on further study of the problem the corner design shown in Fig. 2 was finally adopted.

This all-welded joint was formed by welding the rails on a forty-five-degrees miter, and then welding the corner insert to the rails. An ingenious jig, shown in Fig. 3 was used to clamp securely and to align accurately the various members during welding, and resulted in further speeding the fabrication of the sashes.

Comparative Costs

Comparative costs showed conclusively that the all-welded construction was considerably more economical than the welded and riveted construction. The time required for completing the original corner design was 5 min. 45 sec., whereas the all-welded corner required only 3 min. 10 sec. Moreover, when actual production began, it was found that the all-welded sashes were completed at the rate of 5 to 5½ per hr., which was even faster than the time required when making the comparative tests. In addition, the new design, of course, eliminated the expense of milling, drilling and riveting.

This is a typical instance of how welding costs are governed largely by design. The manufacturer of these aluminum window sashes states that he expects to obtain additional orders as a result of the change to an all-welded product. Welding improved the product and lowered the fabrication cost.

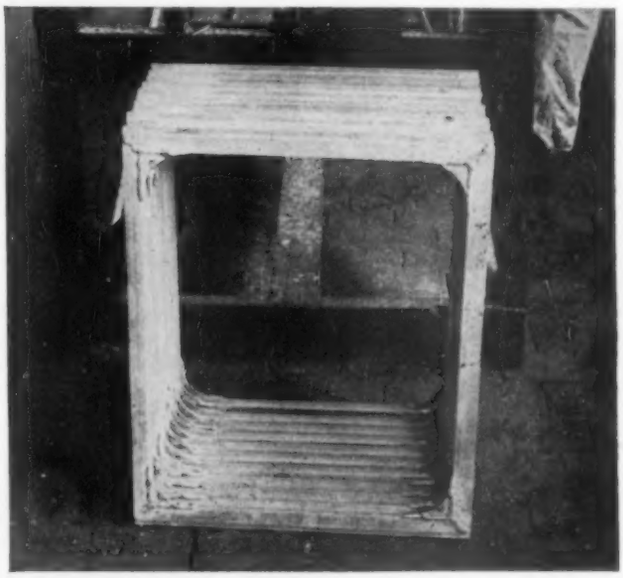


Fig. 4—This Group of Window Sashes Clearly Shows the Welded Joints Which Will Be Invisible When Finally Ground and Polished

THE OXYGEN LANCE PROCESS

By F. E. ROGERS*

ALTHOUGH the burning of a hot steel wire or piece of watch spring in an open jar of oxygen had long been a well-known demonstration showing how oxygen attacks steel, practically no use of the burning process for drilling or separating cast iron or steel had been made until the near beginning of the present century.

HISTORICAL

Gas cutting or burning of iron and steel for industrial purposes began essentially with the oxygen lance process. Use of oxygen and iron pipe for opening frozen tap-holes of blast furnaces was the subject of a German patent granted to Herman A. E. Menne in 1901. A paper on the subject was read by Chevalier de Schwarz before the British Iron & Steel Institute in 1906.

At about this date Mr. Hans Mueller, later president of the Universal Oxygen Company, Sheboygan, Wisconsin, began promotion of the process in the United States for tapping furnaces, burning blasting holes in salamanders, drilling and cutting steel skulls and gray iron castings, and for deep hole drilling of heavy forgings for subsequent boring operations.

The first recorded reference to the use of the oxygen lance process for piercing metals, however, is found in the paper by Thomas Fletcher read before the Society of Chemical Industry, Liverpool, in 1888. The possibility of fusing holes in chilled iron safes was gravely discussed at this meeting. The lance process thus substantially antedated Jottrand's U. S. patent application in 1905 on the oxyhydrogen process of cutting steel plates with the hand torch.

THE OXYGEN LANCE PROCESS

Practical application of the process requires use of lengths of small diameter steel gas pipe, in sizes ranging from $^1/_8$-inch to $^3/_8$-inch nominal diameters. The pipe is screwed into an ell or coupling on a pipe handle which carries a quick-acting control valve, and a hose connection to the source of oxygen supply. The pipe handle is straight, or disposed at right angles to the oxygen pipe, and provided with a loop or other leverage means by which it can be manipulated. Lance handle in line with the pipe is preferred. The oxygen may be supplied by a bank of cylinders on a manifold, or a single cylinder, depending on the conditions and the volume of oxygen required for the job.

CAUTION

In no case should oxygen be used for a lance operation without a pressure regulator, or relief valve. Unregulated cylinder pressure is liable to burst the hose and cause personal injury in case the lance pipe is forced against solid metal, and the oxygen flow checked. Lance pipe must be free of oil or grease.

A spot on the part to be pierced is heated red-hot with the flame of a welding torch, or the preheating flames of a cutting torch. If a cutting torch is employed, a shallow starting hole is burned with it. The free end of the lance pipe is inserted, and a low-pressure flow of oxygen turned on by cracking the quick-acting control valve, or by manipulating the pressure regulator screw with the quick-acting valve open.

The end of the lance pipe takes fire, and the hot spot simultaneously begins to burn. The oxygen pressure is increased to 80 to 110 pounds per square inch, and the lance pushed into the hole as the metal burns, giving it a slight reciprocating and twisting motion as a rule. As the hole deepens, the lance is pushed forward to keep the end in near contact with the hole bottom and to maintain a constant oxygen supply and kindling temperature at the bore face.

Fig. 1—Tapping the Iron Notch of a Blast Furnace with the Oxygen Lance

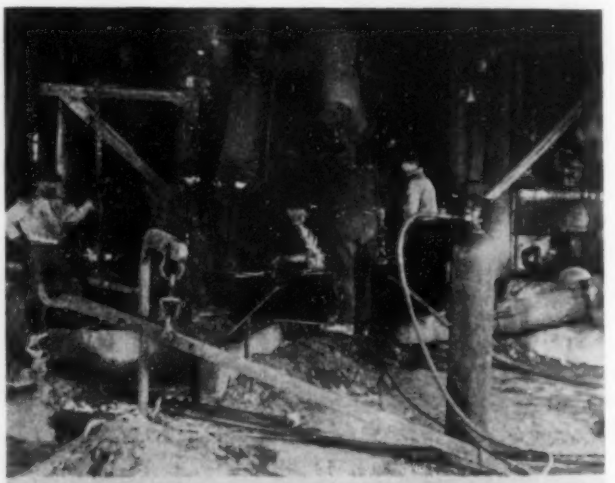


Fig. 2—Molten Iron Flowing from Blast Furnace After Being Tapped with the Oxygen Lance

*Applied Engineering Department, Air Reduction Sales Company, New York.

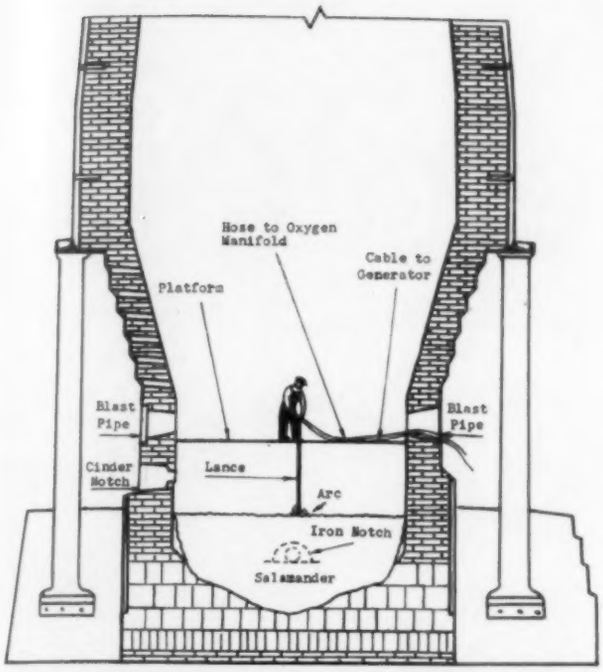


Fig. 3—Blast Furnace Cross Section, Showing Salamander, Working Platform and Lance Operator Starting Lance Operation with the Electric Arc

STARTING THE LANCE

The lance can be started with any convenient kindling. The welding torch flame may be used to heat a spot on the work piece to the kindling temperature, but unless a large tip is employed, it is likely to be slow. The method employed on the cinder dump of a steel plant is to burn a shallow depression in a skull or ladle ingot with the cutting torch. This forms a convenient starting place for the lance when burning blasting holes. A shovelful of live coals thrown into the iron notch of a blast furnace will kindle the lance used for tapping. A method of starting the lance that is especially valuable where the action is required in a more or less inaccessible place requires the use of a welding machine to draw an arc between the end of the lance and the steel to be penetrated. A 200-ampere current, say, at 40 volts is connected to the insulated lance handle, carrying a switch to make and break the circuit. The lance is made part of the circuit with the work piece. When the arc is drawn the oxygen is turned on, and combustion starts at once.

PRINCIPLE OF THE PROCESS

The principle of the oxygen lance process is simply that steel burns in an oxygen atmosphere when heated to the kindling temperature, say, 1400 to 1500° F. The burning pipe furnishes the oxygen atmosphere and maintains the necessary kindling temperature at the bore face. The hole is burned approximately in line with the axis of the lance pipe. Hence, when required to produce a longitudinal hole centrally through a forged shaft, the lance action must be started at the center and "sighted" in line with the axis, the same as though the hole were to be produced with a twist drill.

PIPE FOR LANCE

Standard steel gas pipe $^1/_8$-inch, $^1/_4$-inch, $^3/_8$-inch and even $^1/_2$-inch nominal diameter pipes are used, depending on the diameter and depth of the hole to be burned. Blast holes in steel ladle skulls and ingots are made to a diameter of 2 to $2^1/_4$ inches, or large enough to permit easy ingress of dynamite sticks. When burned to a depth of, say, 18 to 20 inches, $^1/_4$-inch pipe may be used. For burning deeper holes, $^3/_8$-inch pipe reinforced with $^5/_{16}$-inch square rod, is recommended as giving good results with reduced pipe consumption and greater stiffness of the lance. Pipe lengths may be cut in two and threaded so that by the use of couplings they can be completely consumed. This is important on heavy lance jobs where pipe consumption will be large.

SUPPORT FOR LANCE

When piercing holes in a hammer base or similar heavy steel casting to facilitate subsequent Radiagraph cutting, a lance rest should be provided that will assure putting the holes through in parallel with one another and with the base and ends. The rest may advantageously incorporate a shield to protect the operator from flying sparks and slag.

POSITION OF WORK PIECE AND LANCE HOLES

Lance holes should always be burned on the level or pointing slightly upward in order that the slag may escape freely, and thus conserve the lance pipe. If burned at an angle downward, consumption of lance pipe will be excessive due to immersion in slag charged with oxygen. Higher oxygen pressure will be required also to blow out the slag. Hence, the work piece should be tilted or elevated or both to facilitate the lance operations when handling equipment is available. However, the process can be employed to advantage in any position, as a rule, and no concern need be felt about economy of lance pipe on the average emergency job where quick action is required.

LANCE PIPE CONSUMPTION

Length of lance pipe required for a hole of given depth in reasonably clean steel which can be burned in a level or slightly upward direction should be about five times the depth of hole. Thus, a hole 20 inches deep should require about 100 lineal inches of $^3/_8$-inch pipe reinforced with $^5/_{16}$-inch square rod inside. The weight of this pipe with the square rod inside is about 0.89 pound per

Fig. 4—Burning Blasting Holes in Steel Ladle Chill with the Oxygen Lance

foot. The weight of $^1/_4$-inch pipe without square rod inside is 0.424 pound per foot, or less than half the weight of the $^3/_8$-inch pipe reinforced. Hence, the consumption in lineal inches or feet would be fully twice as much, or, say, 200 inches in the foregoing case if the lance were manipulated to make a hole of the same diameter, say, 2 to $2^1/_4$ inches.

OXYGEN CONSUMPTION FOR LANCE OPERATION

Oxygen consumption, of course, may vary widely, depending on the location and direction of the hole burned, the diameter of the hole, quality of steel—whether clean or containing foreign matter—and the operator's manipulative skill. Consumption may be calculated on the basis of one cubic foot of oxygen per one cubic inch of steel burned to make the hole. The calculation must include the steel in the lance pipe also, as is indicated in the foregoing paragraph.

EXAMPLE

What is the theoretical oxygen consumption in burning a $2^1/_4$-inch hole in a steel casting to a depth of 12 inches, using $^1/_4$-inch pipe, the lance being manipulated to produce the required hole diameter?

Steel displaced, $2^1/_4 \times 2^1/_4 \times 0.7854 \times 12$ = 47.7 cu. in.
Lance pipe burned, 200 lineal inches = 18.0 cu. in.

Total = 65.7 cu. in.

Inasmuch as 65.7 cubic inches of steel are burned, the oxygen consumption should be 65.7 cubic feet, or, say, 66 cubic feet per foot of hole, assuming the theoretical cubic foot oxygen consumption per cubic inch of steel burned and displaced is realized.

LANCE OPERATION SPEED

Holes 2 to $2^1/_4$ inches diameter can be burned with $^3/_8$-inch pipe reinforced with $^5/_{16}$-inch square rods inside at the rate of 6 to 10 inches per minute when favorably located, and the steel is reasonably clean. This means that an adequate oxygen supply and a pressure regulator capable of passing up to, say, 3000 cubic feet of oxygen per hour are necessary, or, say, a five-star manifold and regulator assembly with $^3/_8$-inch inside diameter oxygen hose are required.

The lance should be allowed to float along at an even rate. Crowding enlarges the hole unduly and increases the oxygen consumption. When the lance manipulation is discovered that gives the desired hole diameter, it should be continued throughout the operation.

LANCE MANIPULATION

Hence, the manner in which the lance is handled is highly important. If it is crowded or pushed forward with the intention of accelerating the speed, the result will be to produce a large hole and to defeat speed. Refer to the sketch of a lance hole cross section. The concavity *B* directly in front of the lance *A* is produced by the direct flow of the oxygen through the pipe. When the lance is pushed forward, the oxygen is trapped by the edges of the pipe acting like a valve seat. Pressure is built up, and the oxygen escaping burns away the pipe rapidly, and flaring out it burns the larger cavity *CC*. Thus, it is evident that a small pipe, say, $^1/_8$-inch can be made to burn a relatively large hole, or a $^3/_8$-inch pipe allowed to "float" can be made to produce a hole of diameter not greatly larger than the pipe itself. This is illustrated by the fact that a $^1/_4$-inch pipe used to perforate a steel billet can be made to burn the last half inch to a diameter that just lets the pipe pass through.

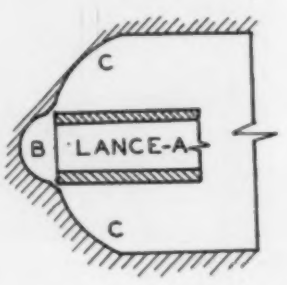


Fig. 5—Cross Section of Lanced Forging Showing How Hole Size Is Controlled

Fig. 6—Burning a Dynamite Blasting Hole in a 75-Ton Cast-Iron Ladle Chill with the Oxygen Lance

Fig. 7—Result of Blast on Cast-Iron Ladle Chill, 9 Feet Diameter Large End, 6 Feet Diameter Small End and 9 Feet Long

LANCE CONTROL

Diameter of holes burned with the oxygen lance and consumptions of lance pipe are then controlled in major or minor degree by the following factors:

1. Lance pipe diameter
2. Lance pipe manipulation
3. Oxygen pressure
4. Direction of operation, i.e., horizontal, sloping upward, sloping downward, vertically upward and vertically downward.

When the objective is penetration only, or when made for starting a torch cut or loosening a tight key in a flywheel, a $^1/_8$-inch pipe can be used if the depth is comparatively shallow. But if the depth is relatively great, a $^1/_4$-inch pipe may be necessary to prevent drooping or wabbling. Black iron pipe of the given sizes is indicated for the several diameters as follows:

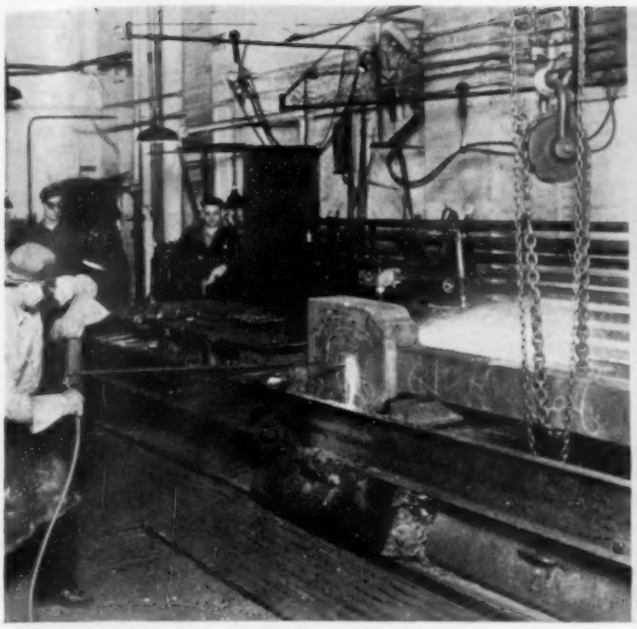


Fig. 8—Burning Starting Hole in Locomotive Connecting Rod with Lance

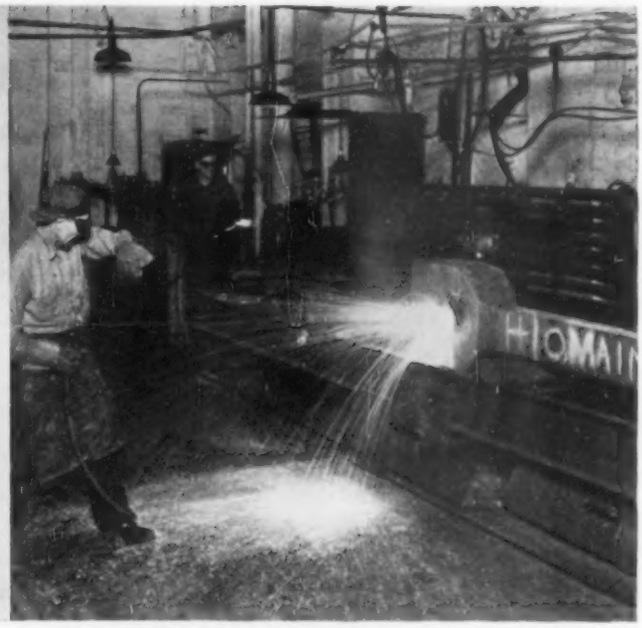


Fig. 9—The Shower of Sparks Accompanying the Lance Piercing Operation

Use 1/8-inch pipe (0.405 inch O.D.) for 1/2-inch to 1-inch holes
Use 1/4-inch pipe (0.540 inch O.D.) for 3/4-inch to 2-inch holes
Use 3/8-inch pipe (0.675 inch O.D.) for 2-inch to 3-inch holes
Use 3/8-inch pipe and 5/16-inch rods for 2-inch to 3-inch holes
Use 1/2-inch pipe (0.840 inch O.D.) for 3-inch to 3 1/2-inch holes

The foregoing larger holes are obtained with the respective pipe sizes by manipulating the lance. When worked back and forth with 4-inch strokes, each forward stroke terminating hard against the hole face, a large hole will be produced, and if twisted as well as oscillated, a still larger hole may be produced. Oxygen pressure obviously is a factor in affecting the hole diameter as greater flare effects are produced with the higher pressures.

LANCE ATTACHMENT TO CUTTING TORCH

When removing locomotive saddle and frame bolts, the use of the oxygen lance often will avoid much heavy labor under difficult conditions. A short lance convenient to use in restricted quarters is made by brazing a 1/4-inch pipe coupling to the tip nut of a cutting torch to serve as a holder. The 1/4-inch pipe is cut into lengths of 12 to 14 inches each, and each piece is threaded at one end. The regular cutting tip is removed, and the tip nut screw into the head with a copper gasket under the shoulder to prevent oxygen leakage. The acetylene hose is disconnected, and the acetylene valve closed tight.

The torch thus serves as a lance handle and quick-acting valve to control oxygen flow. It can be used in close quarters and "aimed" accurately to remove saddle bolts and frame bolts without scoring sides of the holes. The bolt heads are cut off with a regular cutting torch tip, and then the lance torch is brought into play, having first heated the end of the shank with the cutting torch preheating flames. This lance is operated with 40 pounds oxygen pressure, and removes the 4-inch shank of a saddle bolt in less than a minute, with consumption of about 12 inches of the 1/4-inch lance pipe. Thus, a 14-inch length of pipe is required for each saddle bolt.

Labor and material cost are reduced nearly 70 per cent as compared with the bolt-stretching method formerly employed on one railroad. The same set-up may be used to advantage in piercing plates and forgings for machine cutting of inside patterns requiring a starting hole.

LANCE FOR REACHING METAL INACCESSIBLE TO THE CUTTING TORCH

Excess metal inside of long cored castings, or tramp iron in stone crushers that has locked the jaws open and inaccessible to the cutting torch can often be reached and burned out with the oxygen lance. Thus, a difficult machining operation or dismantling the crusher can be avoided.

LANCE CONTROL ASSEMBLY

This assembly consists of a lance valve handle, carrying a quick-acting valve for controlling the oxygen flow. Although designed for use with a regulator, it can also be used with a relief valve which is connected directly to the oxygen cylinder valve when tapping a blast fur-

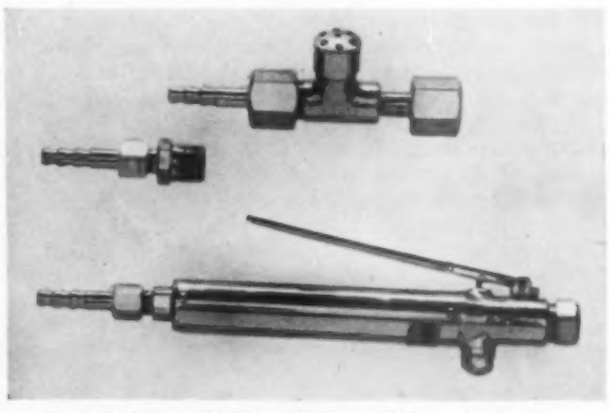


Fig. 10—Lance Handle and Pipe Holding Attachment

nace. The handle is provided with removable bushings permitting use of 1/8-inch, 1/4-inch or 3/8-inch lance pipe. It is also provided with an oxygen lance valve hose connection outlet for use where one operator stands near the oxygen supply and manipulates the valve while another operator handles the lance which is connected to a hose fitting and hose leading to the lance valve assembly.

Thus, the outfit provides for use of the lance as follows:

1. With pressure regulator, hose connection from regulator to lance valve assembly, and lance pipe screwed into removable bushing in end of lance valve assembly;
2. With relief valve only on cylinder, hose connection from relief valve to lance valve assembly, and lance pipe screwed into lance valve assembly;
3. With pressure regulator or relief valve on oxygen cylinder, hose connection from same to lance valve assembly, and hose connection from valve assembly to hose fitting into which lance is screwed.

USE OF LANCE WITH CUTTING TORCH

Cutting of steel risers, foundry spills, ladle ingots and other steel masses beyond the scope of the cutting torch can be accomplished with the cutting torch and the lance in cooperation, the torch leading the cut and the lance operating in the kerf to burn away the metal left by the torch. A large tip used in the torch is oscillated from side to side to make a wide kerf that will admit a 1/8-inch pipe lance. The combination of cutting torch and lance has been employed successfully in cutting steel casting risers up to 90 inches diameter.

ENGINEERING USES OF STEEL

Castings in Welded Structures*

By JAS. THOMSON†

IN DAYS gone by engineers created machines that worked, even though they had only a very limited number of materials to use. These creations, in the light of today, were simple and clumsy but were remarkable considering the limitations imposed upon the designer. Today the engineer has at his disposal hundreds of materials and methods from which to make his selections. Even a very casual examination of any of the materials directories is proof of this statement.

The situation is far from being static however. This may be noted in the ever changing race between castings, forgings, stampings and welded structures. Should the designer favor let's say, forgings then the casting and welding producers get busy with their research men to endeavor to produce new products better either in quality or economy to compete with the forging. Thus we have an ever changing competition which has developed many new and improved products. This, of course, all spells progress.

One of the fundamentals of good engineering design and practice is the selection and use of the proper material for the particular job. The engineer must guard against the wild propagandist who insists that his method or material is the best to use. This fellow usually has an axe to grind which may not be the best tool for the job.

It would be nonsense for the foundryman to say that all structures should be made from castings. It is just as foolish for the exponents of either welding or riveting to assert that their methods are always the best.

There has grown up in certain places a sort of antagonism between the welding industry and the foundry industry. Natural, as that antagonism may have seemed in the beginning, the time has long passed when it should be continued. No doubt it is continued either through ignorance of what the opponent has to offer or for pure propaganda. We are both members of the great iron and steel industry and as such should be interested in producing at a profit to ourselves, structures which will give our customer the best for his dollar, taking both quality and economy into consideration. Competition, of course, we should have but not unwarranted antagonism.

Wherever strength, toughness and resistance to impact, corrosion, high pressures, temperatures and critical stresses are involved one can obtain a steel casting to suit the service conditions.

THE SIZE OF THE INDUSTRY

Throughout the United States there are approximately 175 commercial steel foundries capable of rendering prompt service to all industries. During the year 1937 these foundries produced over 80,000 tons of castings per month. Steel foundries employ a large number of competent engineers, metallurgists and technicians who are schooled to think in terms of correct engineering design, as well as modern foundry practice. They are constantly engaged in experiments and investigations looking toward improvement in the quality of their product, and earnestly seek contacts with designing engineers in all fields to the end that a knowledge of steel foundry practice and technique may be generally understood. They invite consultations in order that mutually satisfactory casting designs may be developed.

STEEL CASTINGS PREEMINENTLY STRONG AND TOUGH

Many people do not differentiate between cast steel and other cast metals. They think of all ferrous castings as being brittle and easily broken. When one sees a

*Abstract of Paper presented at the February 17, 1939 meeting of the Chicago Section of AMERICAN WELDING SOCIETY.

†Chief Plant Engineer, Continental Roll & Steel Foundry Company.

Fig. 1—Frame

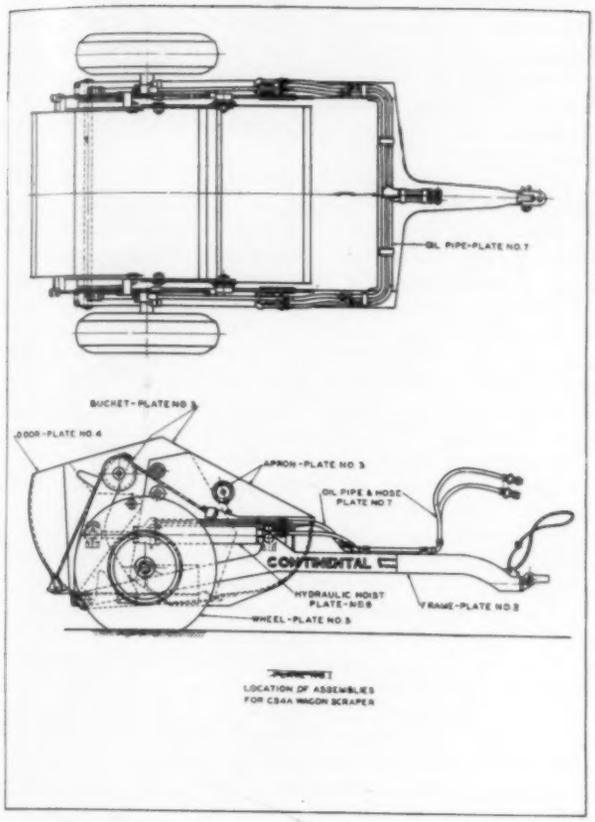
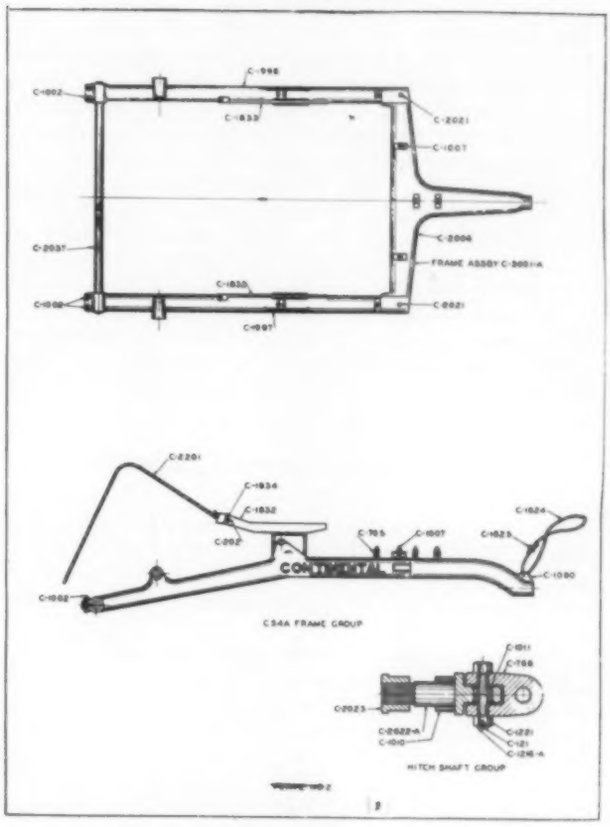


Fig. 2—Frame



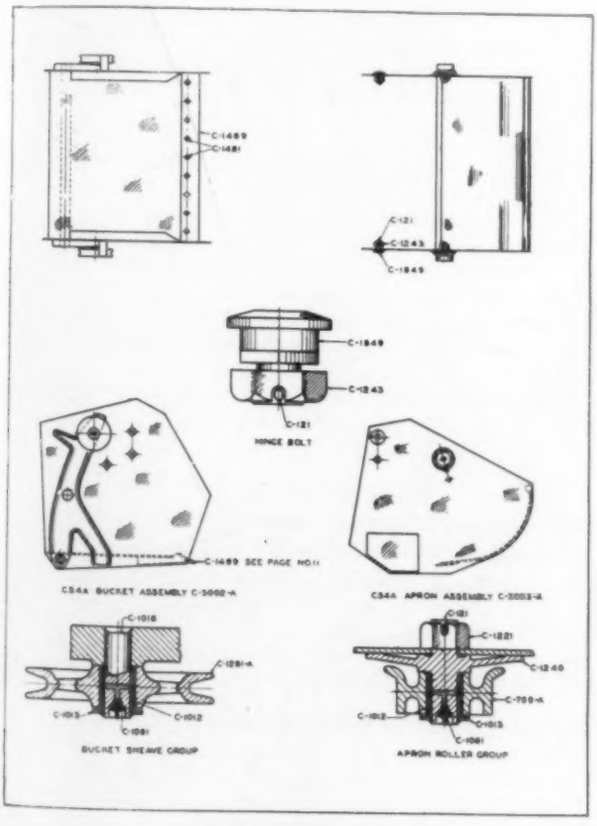


Fig. 3—The Bucket and Apron

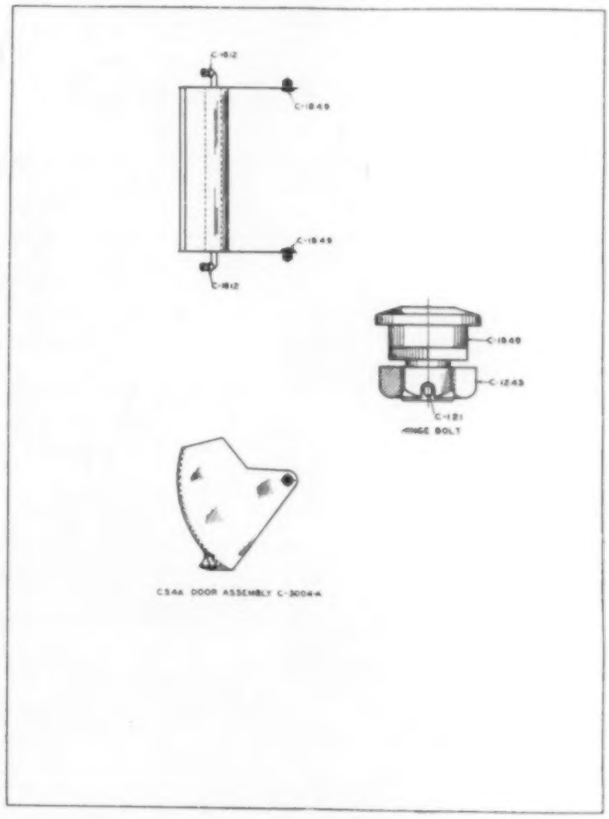


Fig. 4—The Door

tension specimen pulled and the bar stretch out reducing the cross-sectional area to about half that of the original test bar, one begins to appreciate the amazing ductility of this material.

As an indication of how far the industry has progressed since its early days let us take the specification for Grade B steel (a medium plain carbon steel) adopted by the railroads in 1902 and contrast the physical requirements with those called for in the current specifications for this same grade of steel. In 1902, yield point was not specified; today it is 38,000 lb. minimum. Elongation in 2 inches in 1902 had to be 12 per cent or more; today—24 per cent minimum. Reduction of area was not specified in 1902; today this grade of steel carries a 36 per cent minimum requirement. These changes are the more impressive when one reflects that *both strength and ductility* have been substantially increased in these specifications.

MODERN HEAT TREATING METHODS

By selecting a suitable chemical composition and heat treatment almost any desired set of physicals can be obtained, it being remembered that the higher ranges of tensile strengths will be accompanied by lower ductilities.

The heat treatment of both carbon and alloy steels is capable of effecting a wide range of physical properties. Steel castings can be obtained having tensile strengths ranging from 60,000 to as much as 250,000 lb. per square inch. Even in the "as cast" state carbon cast-steel physicals are impressive. However, in the case of certain types of steel, a normalize treatment will increase the tensile properties. With the exception of some low carbon steels the physical properties are improved by suitable heat treatment.

SOME ALLOY CAST STEEL APPLICATIONS

Alloy steels have become a commonplace in the steel foundry. The so-called low-alloy cast steels may be divided into two groups: first, those used to obtain higher physical properties of strength, ductility, shock resistance and endurance values; and second, those steels which are resistant to unusual wear or abrasion because they are susceptible to extreme surface hardening without loss of internal toughness, or characterized by a very high degree of hardness through all sections.

The first group of alloy steels is frequently used to make weight reduction possible without sacrificing strength or toughness.

Examples of the use of the high structural strength alloys are: locomotive crossheads and eccentric cranks, airplane landing gear parts, automobile steering knuckles, and the like. In this group we have Chromium, Medium Manganese, Molybdenum, Nickel and Vanadium either as simple alloys or as combinations of two or more of these elements.

In the wear resistant group of alloy steels are High Manganese, and combinations of Chromium, Molybdenum and Nickel. The apparent duplications of these alloying elements are due to the fact that the amounts of these elements and the heat treatments used determine the group in which they belong. Examples are forming dies, certain types of crushing and grinding equipment and the like. High Manganese steel requires cold working to develop the proper wear resistant qualities.

In this general group of wear resistant alloy steels are those that may be carburized or case hardened, including certain Nickel-Molybdenum and Nickel steels, as well as nitriding steels. Examples of use are cams, certain types of gears, valve seats, precision guides, etc.

The growing demand in recent years for metal parts to resist oxidation and distortion at elevated temperatures, and to withstand the corroding action of acids, alkalies, etc., at normal and elevated temperatures has been met by the foundry by utilizing certain alloy combinations, suitable for the production of castings far superior to ordinary steels for these specific purposes. Up to the present time, Chromium and Nickel have been the predominating alloying elements used in this field, although Molybdenum, Tungsten, Silicon, Manganese and other elements are employed advantageously for special applications.

In many applications using these alloys, other characteristics are more important than tensile properties, such as resistance to creep or growth at elevated temperatures over extended periods of time, or resistance to the corroding influence of certain gases or liquids.

CASTINGS AND WELDING

Castings, welding and riveting each have a very definite place in the design of structures and the decision as to which one or combination to use can be readily arrived at by a little serious and unbiased study with *all* the facts before one. In the last analysis, the economics of the job under consideration should be the determining factor.

When only a few pieces are to be produced I think we

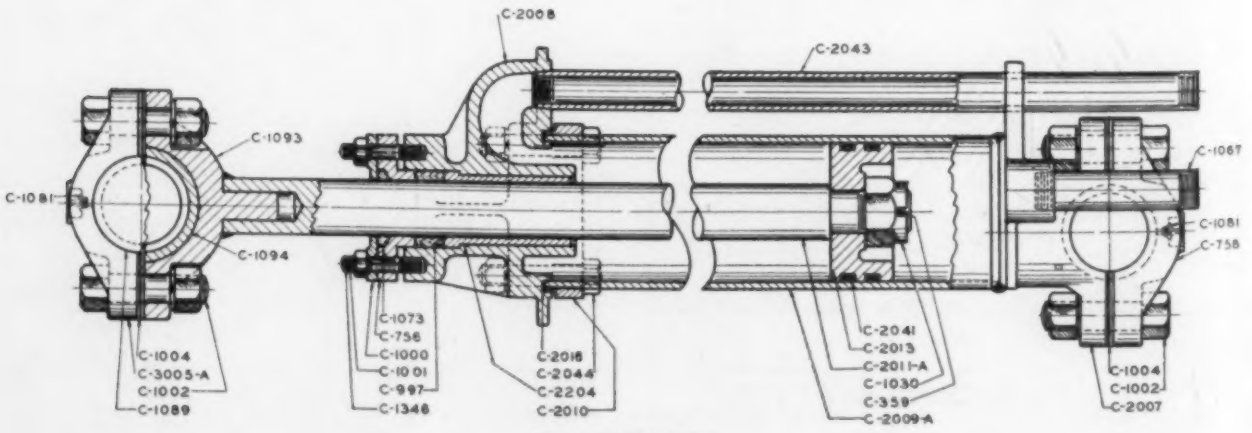


Fig. 8—The Cylinder

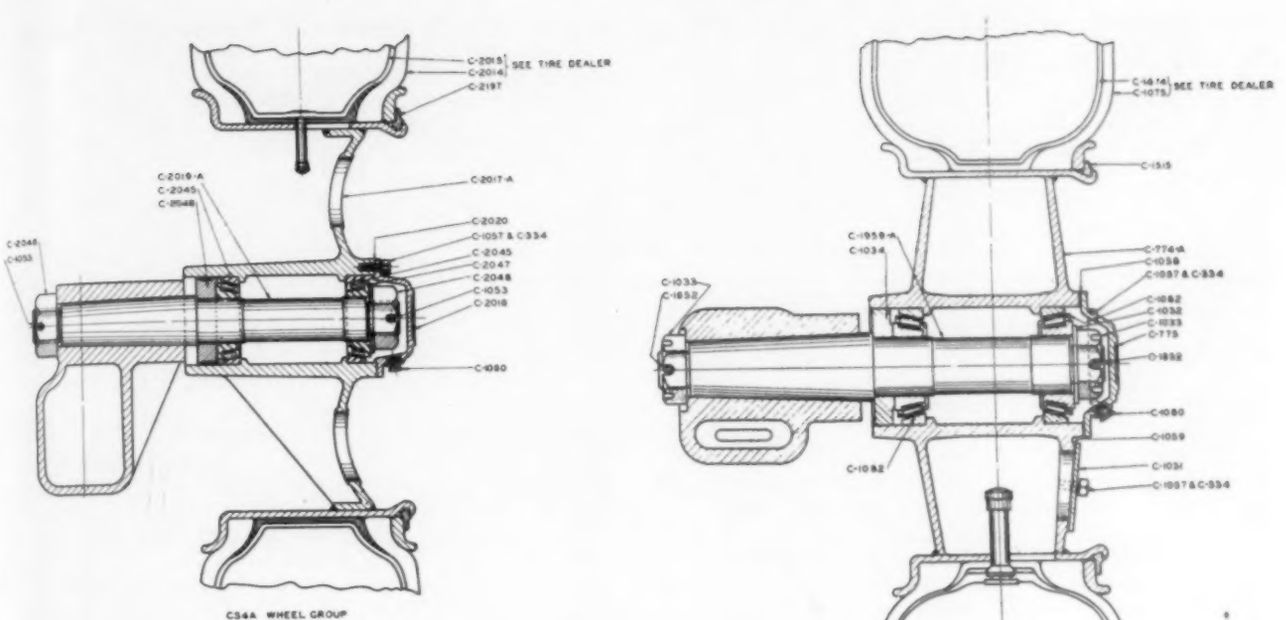


Fig. 6—The Wheel

all agree that in many cases the economics of the job indicate that a welded structure should be made. However when we get into jobs that are for quantity production, the problem becomes more complex and more study is needed regarding both materials and methods. Perhaps welding is the best answer or perhaps castings alone or a combination of welded steel parts and castings are best.

As an example of what we consider the proper approach to the problem I want to give you a description of a machine which we build which is engineered to produce what we consider the most efficient design for use, without bias as to any particular material or method.

Before starting the description may I state that our company's set-up of shops and equipment provides the means for using castings, welding, machining or riveting and the engineer, therefore, has at his hand the choice of the best and at the same time the most economical method and material for his purpose. With a steel foundry, a welding shop and a machine shop at their command, our engineers are free to use their best judgment as to materials and methods of production.

CONTINENTAL WAGON SCRAPER

The machine I am about to describe is termed the Continental Wagon Scraper. This scraper being a quantity production job, every detail was studied carefully, first for proper design and second for economy in production. In fact this study goes on more or less constantly as a penny or dollar saved is reflected in either profits or sales price.

This Wagon Scraper is used in the construction field for digging, carrying and dumping dirt. It is drawn by a tractor and is operated hydraulically from a pump and valve mounted on the tractor.

The main units comprising this scraper are: (1) Frame, (2) Bucket, (3) Apron, (4) Door, (5) Cylinders and (6) Wheels.

1. *Frame*, The design of the frame was decided upon after rather extensive engineering study of all factors. The illustrations, Figs. 1 and 2, show that it has a rectangular shape with a tongue in front, with necessary parts to connect it to the tractor, machined bosses for carrying the wheel axles and means for holding and clamping the shaft which carries the bucket. A study of the shape arrived at, the stresses involved in its use and the machining necessary lead to a decision to use heat-treated alloy castings for its construction. Further study developed the economy for the foundry and machine shop of making it in three castings, the tongue C-2006 and the two side pieces C-1997 and C-1998 being these three parts. The forward ends of the side pieces and the ends of the tongue are designed to form a sort of tenon joint and are welded together at these points on assembly. The stresses set up at these points are rather high in the field so after welding, a hole is drilled through the joint and a tight pin C-2021 driven through. This pin is then welded into the castings.

On the upper face of the side pieces is a bracket which carries a ball shaped pin. This pin carries the rear of the cylinder and transmits the reaction of the cylinder to the frame. These are integral parts of the castings. On top of these brackets are odd-shaped tracks or guides C-1832 and C-1833 These units are also used for the dead end of the door cables. These are alloy castings, used in the rough but welded to the frame bracket.

The seats for the hydraulic piping are cast integrally but the studs which hold the pipe clamps are welded to the frame.

The machining of the parts of the frame is handled in fixtures and jigs and is completed before assembly and welding. The parts are placed in a jig for welding so that when welding is complete the frame is in perfect alignment. Thus we have in this frame a structure which because of its particular shape, the machine work necessary, the stresses involved, etc., would be an extremely expensive job for welding from structural steel. Being a quantity production job the foundry and ma-

chine shop were able to rig up to produce the castings economically.

2. *The Bucket*, C-3002-A, Fig. 3, is a good example of a composite structure. The bucket proper is built up of plates of special analysis continuously welded at all intersections and reinforced with structural steel members welded to the plates. The pivoting member consists of a tube welded to the bucket along the rear lower edge. The forward lower edge of the bucket carries a renewable cutting edge C-1469. This cutting edge does all the work of digging and is subject to severe punishment in service. A suitable and adequate method of holding the cutting edge to the bowl had to be developed. Study indicated that for strength and economy a heat-treated alloy steel casting was the best solution. This casting is securely welded to the plates of the bowl.

Members were required to function as side stiffeners for the bucket and to carry cable sheaves and ball shaped members for receiving the push from the cylinders to tilt the bucket. The study of this member also indicated a steel casting as being best adapted to the job. This is welded with a continuous weld to the side plates. The ball shaped part which connects to the piston head of the cylinder is cast integrally with the main casting as is also the cable guard. It makes a very simple and effective member.

3. In *The Apron*, C-3003-A, Fig. 3, we have an example of an economical unit built up of sheared and bent plates continuously welded. There is a pipe stiffener welded to the upper edge. This part also indicates economy in design.

4. *The Door*, C-3004-A, Fig. 4, also illustrates the economy of plates and welding. It is made of structural materials with the exception of the fittings C-1612 on the lower corners which because of their peculiar shape are steel castings. These fittings are welded to the door.

5. *The Cylinder*, body C-2009-A, Fig. 5, is a steel tube to which is welded at one end a cast-steel head C-2007 and a bolting flange C-2010 at the other end. The flange is welded to the tube before boring the tube. The head is machined to fit into the bored tube and is welded after the tube is bored. The outer end of the piston rod is counterbored to receive a finished projection on the cap-like end C-1093 which is pressed into this counterbore and also welded to the rod. This end piece is a steel casting as are the caps C-3005-A which are bolted to it and the cylinder head.

6. *The Wheel*, Fig. 6, is a composite of a cast steel hub and web unit C-2017-A welded to a rolled steel rim C-2197. The cap C-2018 is a steel casting bolted to the hub. It carries the company's monogram and a boss for the lubricating fitting both cast integrally with the cap.

There are other miscellaneous parts such as sheaves, rollers, drawbar, clevis, special bolts, etc. The material and design of each was selected with due regard for efficiency and cost. Some are steel castings, others are from rolled steel.

Arc welding is used exclusively on this scraper.

In conclusion, may I reiterate that each job should be a separate engineering problem in which each part should be given unbiased consideration as to both quality and economy.

I wish to acknowledge my indebtedness to the Steel Founders Society for some of the data and statistics used in this paper.

A WELDED ELEVATOR MACHINE*

By JOHN N. ANDERSON†

IN THE elevator industry, a manufacturer of elevators must be prepared to furnish machines in sizes ranging from those capable of handling loads of less than 100 lb., as for small dumbwaiters, to those of sufficient capacity to handle the largest trucks to be found on our highways at the present time. The speeds at which these loads are carried may vary from less than 50 f.p.m. up to 400 f.p.m. for passenger or freight elevators and may be as high as 1000 f.p.m., or even higher, for passenger elevators.

When preparing a line of machines to cover the wide range of duties mentioned, it is essential that the sales and engineering departments cooperate to the end that the sales requirements may be completely covered with as few different machines as is economically possible from a production standpoint.

In conjunction with our sales engineers, a line of machines was planned which would cover all the normal requirements, or duties, which we might be expected to meet. The lower and intermediate duties presented no difficulties in design or manufacture as the sales expectations were of such proportion as to allow any pattern or tool charges to be spread over and absorbed by a great many units. In the highest brackets, however, where the duties to be met comprised very heavy loads at comparatively high speeds, past experience indicated that the demand would be very small, and that the pattern and tool expense would have to be spread very thick over each unit sold, thus adding enormously to the factory cost and lowering our competitive advantage to the point where even fewer sales would be made.

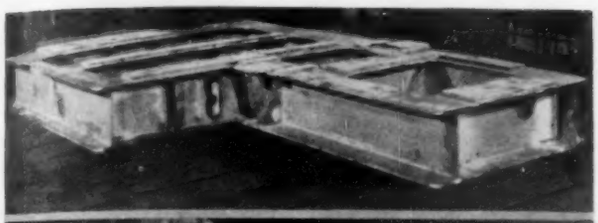
Under these unpromising conditions, the task of designing a suitable machine for the unusually heavy loads and high speeds was handed to our department.

During the years since the advent of the gearless traction elevator, the elevator-riding public has come to regard vertical transportation as being practically noiseless. They are satisfied to ride to the business centers in busses, trolley-cars or subway trains amid noise that renders conversation an impossibility; yet, when they arrive at their offices or stores, they expect

* The author of this paper received the fourth main award, $1526.33, in the Functional Machinery Classification of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding. The paper, reproduced here in brief form, contains approximately 11,000 words, 28 drawings and 7 photos.

† Designing Engineer, Otis Elevator Company, New York, N. Y.

Fig. 1—The Bed Plate of the Elevator Machine



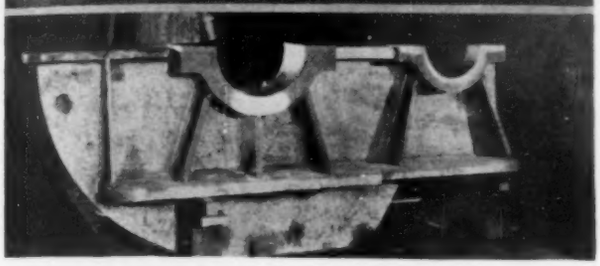


Fig. 2—The Front Sub-Assembly Welded

their elevators to be smooth and silk-like in operation. This expection has now spread to elevators of the geared freight type and where, a few years ago, a freight elevator which carried the load up or down in any fashion at all was good enough as long as it ran, nowadays any perceptible noise is deemed sufficient cause of complaint. It will, therefore, be understood that in studying and designing the machine which is to be described, no effort was spared in eliminating the possible causes of gear noise.

One well-known cause of this noise is slight variation of center distance or of alignment of gears due to deflection of machine parts. To overcome this, we realized that the gear case, which also supports the pinion bearing and one of the bearings of the gear and sheave shaft, would have to be made as rigid as possible without being ridiculously bulky.

A motor which would develop the torque to meet our requirements and a brake suitable for the motor both being available, the sizes of the sheave, gear and pinion were quickly determined and a preliminary design was made on the basis of using iron or steel castings for all the various parts except shafts, pins and the like.

The first design consists of a driving, or traction, sheave grooved for hoisting ropes and a single helical gear, both mounted on spiders, or centers, which are integral through a connecting neck. These spiders and their connecting neck are called the "gear and sheave center," and are arranged on a shaft carried on double row tapered roller bearings located at the ends of the shaft. The bearings are of special design with a narrow seat on the periphery of the double cup to allow a moderate amount of misalignment and are contained in suitable housings, one of which is part of the gear case, and the other a part of the outboard bearing stand.

The outboard bearing housing is provided with caps or covers which retain the grease for the roller bearing. This roller bearing is not constrained against end-wise movement in its housing, being left free axially to find its own location.

At the opposite end, the bearing housing is in two halves, one of which is integral with the upper gear case and the other integral with the lower gear case. This bearing housing is provided with an outside cover and an inside half-cover which extends only as far as the joint between the upper and lower cases. The thrust, caused by the axial component of the helical gear pressure, is taken by the tapered roller bearing which is located in this housing and is constrained against axial motion through collars and aligning rings with spherical surfaces as shown abutting against the double cup of the bearing and covers. This bearing is supplied with oil provided by "splash" from the gears.

The cast-steel helical gear meshes with a pinion which is supported on single row tapered roller bearings located closely adjacent to the side of the pinion. These bearings are mounted in housings which are a part of the gear case. Integral with this pinion, is a shaft which extends through one of the roller bearings and is connected to the shaft of the driving motor through a combination brake pulley and coupling.

The outboard stand, gear case, brake stand and motor are all mounted on a continuous cast-iron bedplate, thus combining the various parts of the elevator driving or hoisting mechanism into a single unit.

The brake used is one in which the shoes, mounted on brake levers, are magnetically released and applied by means of a spring when the magnet is de-energized. Thus, the brake is applied when the machine is stopped and released as soon as the current is simultaneously supplied to the motor and brake magnet.

The design of the cast machine was the last of several studies which were drawn up. No detailed working drawings were made but the study was shown to scale and in sufficient clarity to enable a close estimate of works costs to be prepared. These costs covered the

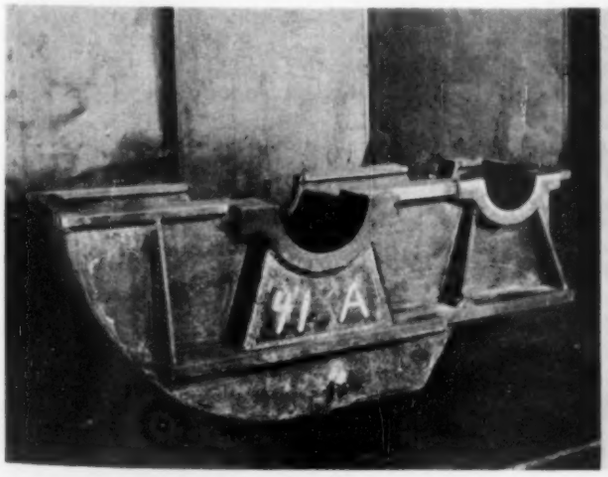


Fig. 3—The Finished Gear Case

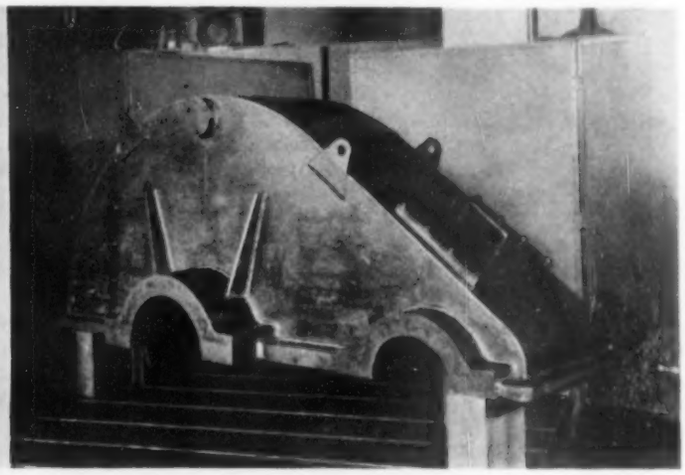


Fig. 4—The Upper Gear Case

complete machine including motor, brake and sheave, as well as the parts which are included in the cost and weight comparisons tabulated later.

The pattern cost, which is considerable, is given separately and is not entered as a part of the cost of the machine although we might fairly distribute this expense equally on the first 25 machines to be built.

In estimating labor costs, the unit of time is taken as one minute. The hourly wage is 80¢ and, allowing for 200% overhead, the hourly rate becomes $2.40 or 4¢ per minute.

The prices of iron castings weighing less than 100 lb., or more than 100 lb. where core work is involved, is 6¢ per lb. For castings weighing more than 100 lb. and without core work, the price is 5¢ per lb. For large steel castings such as the gear rim used on this machine, the price is 10¢ per lb.

On the basis of these costs, the estimated cost of the machine, built with cast-iron and cast-steel parts, would be too high to enable us to hope to compete successfully on sales of the maximum duties and still make a reasonable margin of profit. During the past few years, the writer has, from time to time, designed many parts for various special machines where, on account of the high pattern cost, welded steel instead of cast construction was used. He, therefore, volunteered to design a machine which, with the exception of the motor and brake, would be made principally of welded steel. This would not only eliminate the pattern costs of the proposed machine but, because of the greater stiffness of steel over cast iron, would allow enough saving of weight so that the steel machine, when completed, would probably be more rigid and cost less than the cast machine even without considering the pattern expense.

Studies were begun and after the usual numerous changes of mind and ideas, which are never evident in the finished machine, the design was prepared.

The Arc-Welded Design.—This machine, in regard to gear sizes, sheave and arrangement of parts, is practically identical with the cast machine. In all essential parts, we have made the welded machine at least as stiff and usually stiffer than the equivalent cast construction.

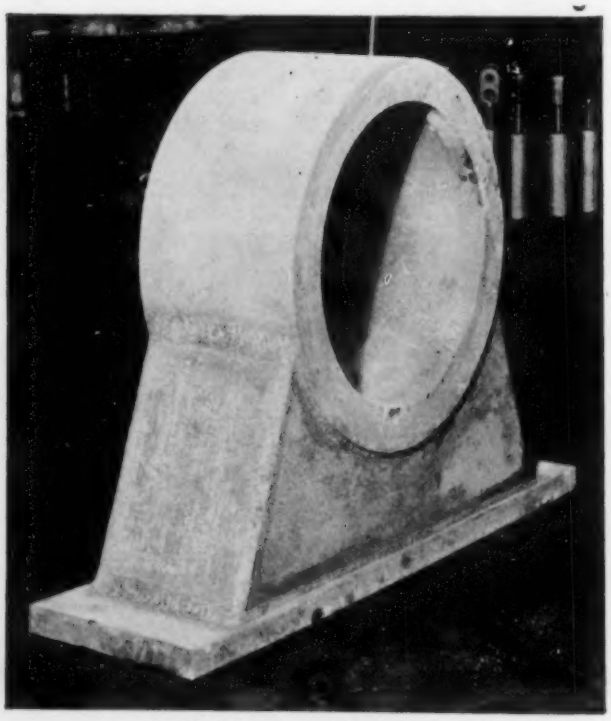


Fig. 5—The Sheave Shaft Stand

Bed Plate.—The bed plate as shown in Fig. 1 serves as a base for the various parts of the machine. These parts are the motor, brake, gear case and the outboard bearing stand of the gear and sheave shaft. This bed plate is not unusual in construction, being built up of standard structural shapes.

Gear Case.—The gear case is fabricated entirely of rolled steel. The first welded design contemplated the use of steel castings for the bearing housings and rolled steel for the remainder. However, due to the high cost of steel castings and the possibility of their being porous, and since no difficulty was expected or experienced in flame cutting the housings to shape from steel slabs, the rolled-steel construction was adopted as the more satisfactory.

The lower gear case has a vertical plate on the near side flame cut to the desired shape from $^1/_2$-in. steel plate and with bearing housings, flanges, ribs, foot shelf, etc., welded to its front surface.

On the far side of the gear case, the construction is practically similar to that of the front side, except that, instead of the large bearing, there is a reinforced opening comprising a stuffing box to permit the passage of the gear and sheave shaft. The thickness of the plate is $^1/_4$ in. instead of $^1/_2$ in. as on the front side.

The cross members, forming the bottom of the gear case, consist of three parts of varying thicknesses. All of these pieces are of proper width to be flush with the outside surfaces of the side plates. One of these pieces is $^1/_4$ in. thick, bent to suit the contour of the side plate, and extends from the left-hand side of the gear case to the $^1/_2$ in. thick horizontal piece. The piece comprising the right-hand end of the case is $^1/_2$ in. thick.

As assurance against oil leakage, bent-up angle pieces are welded to the inside of the gear case to provide an oil barrier or trough at the joint. Occasional holes, drilled in the bottom of this trough, provide for drainage of accumulated oil.

A $^3/_8$-in. plate, bent to a channel form in a press brake, extends across the inside of the gear case just below the small bearings. This channel serves the several purposes of providing an auxiliary oil reservoir into which the pinion teeth dip, keeping the proper oil level around the roller bearings and adding great lateral stiffness against the changing of the distance between the roller bearings due to the applied external forces.

In assembling and welding the gear case, we placed the front plates, already flame cut to the desired shape, flat upon a platen and assembled the bearings, flanges, foot piece or shelf, and ribs in their proper positions on the plate, tack welding them into place. This sub-assembly is shown clearly in Fig. 2.

Before beginning the welding, the tack-welded front sub-assembly was very securely clamped to the rigid platen and then the parts were welded. In addition to the parts shown in Fig. 2, the $^1/_2$-in. plate was cut to fit the bottom contour of the large bearing and welded into place.

After welding, the piece was allowed to remain clamped until cool when it was removed and carefully inspected for warpage. To our surprise and gratification, no discernible warpage or distortion was evident.

The back plate of the gear case was then assembled and welded in the same manner and with as little difficulty.

To assemble the front and back plates with the cross or bottom plates presented no great problem and was easily accomplished. The finished gear case is shown in Fig. 3.

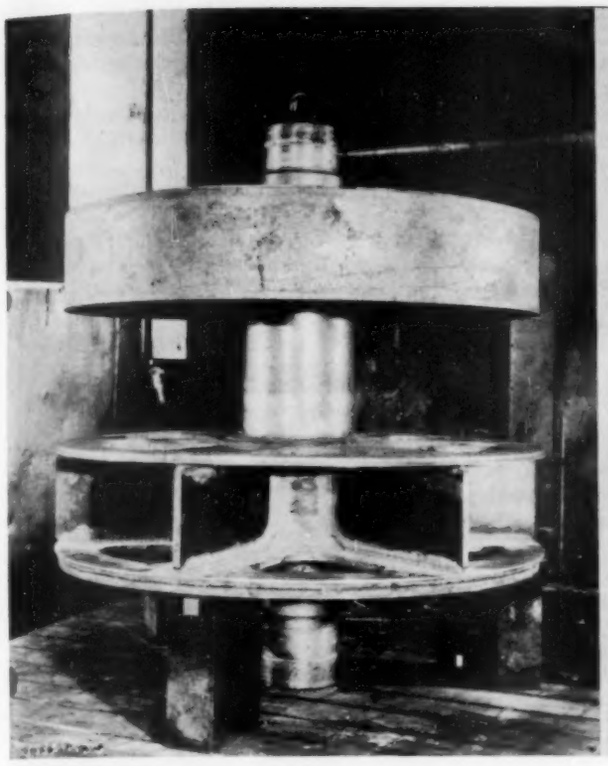


Fig. 6—The Sheave Spider and Gear Spider Nearing Completion

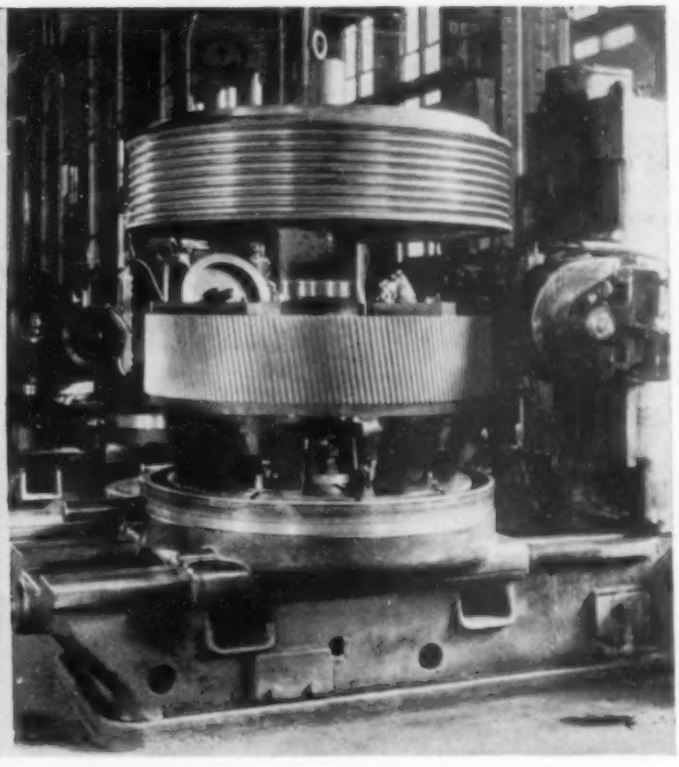


Fig. 7—The Assembly of Gear and Sheave Shaft with the Gear and Sheave in Place

The upper gear case (see Fig. 4) is made to fit on the lower gear case, and the similarity of construction is such that a detailed description would seem repetative.

After welding and stress relieving, this gear case as well as the lower gear case were planed on the horizontal finished surfaces—namely, the joints between the upper and lower case, and the bottom of the supporting shelves on the lower case. The upper and lower cases were then bolted together and the holes for the roller bearings as well as the opening for the gear and sheave shaft were bored. Next the various holes were drilled and tapped and all other work was completed.

Sheave Shaft Stand.—The sheave shaft stand, or outboard bearing stand, is designed to contain a double-row tapered roller bearing which will be subjected to a maximum radial load of 70,000 lb. The direction of the applied load may vary from vertically downward to 45° from the vertical. All of the parts comprising this stand are of steel S. A. E. 1020.

The construction is very simple and direct with straight lines used wherever possible. The housing is made from a ring bent to cylindrical form and welded. The base is 40 in. long x 11 in. wide flame cut from a $1^1/_2$-in. steel slab. The middle strut connecting the base with the ring is a piece 9 in. wide x $5^3/_4$ in. long x 1 in. thick double beveled at each end. The 9 in. wide x $13^1/_4$ in. long x 1 in. thick pieces which form the ends of the rectangular section are beveled at 40° on the lower end. The 40° bevel at that point affords ample space to apply the weld metal on account of the increase opening due to the slope of the parts. The upper end, left square, makes a natural angle with the outside surface of the ring and is approximately correct to obtain a 100% weld with the ring.

Welded, the stand resulted in a tremendously strong and rigid support for the large roller bearing and deflection in this member under the load of 70,000 lb. will be practically nil.

Reference to Fig. 5 will show that the appearance is pleasing and in harmony with the bearing located on the front of the gear case.

Sheave Shaft.—The sheave shaft, with the gear and sheave centers or spiders welded to it, was the last of numerous studies made on this unit. Even after welded design was adopted for the bed plates, gear case and outboard stands, we still continued to show the same construction on this unit as on the one described for the machine where the above parts were of cast iron. The reason for this persistence is that it was difficult to dissociate the gear and sheave centers from an integral connecting neck or hub forced on a shaft. Even after deciding that welded construction for this piece would at least save the cost of the quite expensive patterns which would be required, we continued to show a common hub of steel forced on a shaft. Finally, however, the fact seeped into our minds that boring a hole in a steel hub and then filling it up with a shaft was not consistent with the desired economy.

The actual assembling and welding of the various pieces in their positions were not difficult, but the job was done by an expert layout man and welder and the result justified the care and skill used.

Rings were formed on bending rolls and the joints butt welded. No difficulty was experienced and no particular routine was followed in performing the specified welding. Figure 6 shows the unit nearing completion.

The welding completed, the unit was placed in the annealing furnace and stress relieved. In this case the usual procedure of holding at 1150° F. for one hour for each inch of the thickest part was not followed as the $12^1/_2$ in. diameter shaft was in no need for stress relieving except at those portions where it was joined to the end plates and webs. Therefore, it was arbitrarily specified that this unit should be held for six hours at 1150° F. and then allowed to cool slowly in the furnace to 200° F.

A careful inspection revealed no cracked welds and no distortion. It was necessary to be very particular in the welding of this unit, especially at the points where the plates or disks are joined to the shaft. The load on the sheave will be 100,000 lb. and, as the shaft revolves, any stresses in the welds, due to the applied load, will be subject to reversal which is apt to spell fatigue failure if the weld is not properly made.

After stress relieving, the finishing was completed.

Helical Gear.—The helical gear consists of a ring of steel S. A. E. 1045 and a continuous internal flange flame cut to size from steel S. A. E. 1020. The ring and flange are welded together as shown in Fig. 7. The teeth are single helical and of such pitch and helix angle that there are exactly two axial pitches in the face width, thus insuring that the same number of teeth will always be in contact; the contact lengths will always be the same; and vibration, because of variations of length of contacts, will be eliminated.

After welding, the blank was stress relieved and machined to size. The teeth were cut and then the gear was forced on the gear spider and fastened with twelve 1-in. bolts through the flange.

The assembly of the gear and sheave shaft with the gear and sheave in place is shown in Fig. 7.

Savings by Arc Welding.—Savings in cost and weight by arc welding on comparable parts, including bed plate, upper and lower gear case (less covers), gear case covers, sheave shaft bearing stand (with covers), sheave shaft assembly (less gear and sheave) and finished helical gear blank are:

Cost Savings

Saving per machine = \$1509.80 − \$961.69 = \$548.11
Cost of patterns = \$3425.00
If amortized over 25 machines, pattern cost per machine = 137.00

Saving, welded over cast = \$685.11

Percentage cost of cast over welded construction including patterns based on total of 25 machines = 71½%

Weight Savings

Saving per machine = 21706 lb. − 13300 lb. = 8406 lb.

The costs and weights of the cast and welded constructions show that from both angles there is a decided advantage in favor of the welded machine. The cost of the cast construction is approximately 55% higher than that of the welded and the weights are in about the same proportion. If the pattern costs are also taken into consideration, the difference will be greatly increased and if these pattern costs are amortized over a reasonable number of machines, say 25, the difference becomes so great that cast construction should not even be considered.

The greater weight of the cast construction also may not be neglected as it indirectly adds to the gross cost of the elevator installation in the following way. The machine and its suspended loads must be supported on beams which span the hoistway. The heavier machine requires heavier beams which add to the cost. The building structure, by which these beams are supported, must also be heavier at still more added cost, etc., etc.

Without half trying, one is forced to the inevitable conclusion that the welded machine is the only one that you dare build.

"But," you may say, "what of the appearance? Will not cast construction lend itself to smoother outlines, rounded corners, large fillets and absence of visible joints?"

Perhaps, but no one gives much consideration to these features nowadays. The engineering profession and the manufacturers are so rapidly becoming "welding minded" that a well-engineered and well-executed welded design has more of an appeal than the round corners, tapered flanges and large fillets of the conventional casting. Where are the beautiful (?) curved legs that we saw on the lathes and other machine tools of 25 or 30 years ago?

It is the writer's opinion that a welded design should not attempt to simulate a casting at all. He also believes that the first consideration in welded machine parts should be that all the metal is placed to the best advantage according to engineering principles. At the same time he does not believe that a design should be approached with a slovenly attitude of mind such as "It looks good enough. It's only welded."

As an example, if you will refer to Figs. 3 and 4, it will be noted that the outside corners of the gear case are square, with no visible joints. This was mentioned earlier in this paper. The joint, as first contemplated, was made with a re-entrant angle at the corners to facilitate the welding which could then be made on the outside. At practically the same cost, the corners were made with the plates flush with each other and with greatly improved appearance and no sacrifice in the construction from an engineering standpoint.

And while on the subject of appearance, it is our opinion that no attempt should be made to conceal welds. A well-executed weld is beautiful enough in itself and, on a small scale, it is as great a pity to disguise it with filler and paint as it would be to carry out the original intention and conceal with masonry the beautiful outlines of the steel towers of the George Washington Bridge.

We began the design of the welded machine as described with the belief that it would save the cost of expensive patterns and the hope that it might cost even less than the cast machine on the basis of five machines per year. As a result of our study and actual experience, we know that on the basis of any number of machines per year, five or five thousand, the welded design would still be preferable from any viewpoint—weight, cost, strength or appearance.

We have several other large machines which might also show to good advantage if made of welded rolled steel. We shall see.

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FABRICATED ARC WELDED

Sheet Steel Line Truck Body*

By FRED S. BEACH, SR.†

THE principle problem in the design of this equipment was to obtain the most value for the least expenditure of cash which was accomplished without sacrifice to crew convenience, efficiency of the unit or sturdiness in construction. In deciding the question of chassis capacity, preliminary study of tentative design based on the previous experience of the designer (who is also the author of this paper) in body building, coupled with investigation of stock body designs and those developed by other power companies, it was found that what had gone before and the results of the efforts by the commercial body builders and the results of the work of other companies in body development would produce heavier body weights than was desirable for the unit under construction. These heavier weights we found were in a range between 2700 and 3000 pounds.

Such body weights when combined with the weight of the equipment, tools, materials and crew would require the purchase of a chassis in the next heavier weight class than the one which was finally decided upon and purchased. It was certain that the body of the size that this one is could be built in steel fabricated from sheet and arc welded within the above weight range in simple open-hearth steel with accompanying possibility of using riveted construction instead. However, as previously stated, the weight range mentioned was out of the question. Likewise, if the body were constructed of wood and fitted with forged reinforcements the weight we knew from our own experience would be far beyond this range. The natural course would have been to avail ourselves of the benefits of making a steel body fabricated from sheet steel now available of extremely high strength and yield point and highly resistive to the effects of corrosion.

After preparing a design and computing the weight of a body built from it using this character of material, our selection was a high-tensile steel not available at the time of any previous body design development by the company for which this body was built. Our computations indicated that a body in which high-tensile steel was the major material used would have a weight in a range between 1800 and 2000 pounds.

After completion of the body and weighing the vehicle, we found that the resulting weight of the body was 1958 pounds.

By way of explanation, our procedure with this unit was: After its purchase and delivery it was weighed before any additional equipment was put on the chassis, after installing the winch it was again weighed and the first weight deducted from this last one represented by the difference in weight of the winch and its necessary accessories. After the body was added, a similar procedure was resorted to and all accessory equipment attached during the construction of the body was carefully weighed before being permanently installed, such as reinforcements for trailer coupling as well as the coupling itself, the stiff legs and their accessories; as these later two groups are not actually a part of the body, these weights were deducted from the over-all weight obtained after completion of the body. Reverting to the preconstruction period, our weight and loading schedule showed us that we could purchase a chassis rated to weigh 15,000 pounds inclusive of body and equipment, fuel oil and water and the pay load. Had we been forced by having a considerably heavier body than the one we built into the purchase of a heavier chassis or one of 20,000 gross loaded weight, our cost of the chassis would have exceeded that of the one purchased for $650.84.

The design is based on a construction in which the cross members of the body rest directly upon the truck sill or frame channels depending upon the side wall construction for longitudinal strength without longitudinal body sills to form an independent body underframe. The cross members may be seen in Fig. 1.

The superstructure at the sides of the body is formed by a system of posts in two sets. From their junction with the cross members to which they are welded, these posts extend vertically to a point $18^{3}/_{4}$ in. below the top rail where the channel flanges are miter cut and the web bent over to form rafters which support the roofs over the spaces formed between the outer and inner post systems. At the miter cuts in the flanges of these outer posts, the section is bent over and is arc welded with full penetration butt welds; and where the rafter portion of outside posts joins the inside post, their ends are similarly butt welded also with continuous bead full penetration weld. The inside posts extend vertically from the cross members but spaced $10^{1}/_{4}$ in. inward from the outside faces of the outside set of posts. At each cross

Fig. 1—Cross Members of the Body of the Truck

* The author of this paper received the second main award, $2543.88, of the Automotive Classification in the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding. The paper, reproduced here in brief form, contains approximately 9200 words, 2 drawings and 18 photos.

† Designing Engineer, Northwestern Electric Co., Portland, Ore.

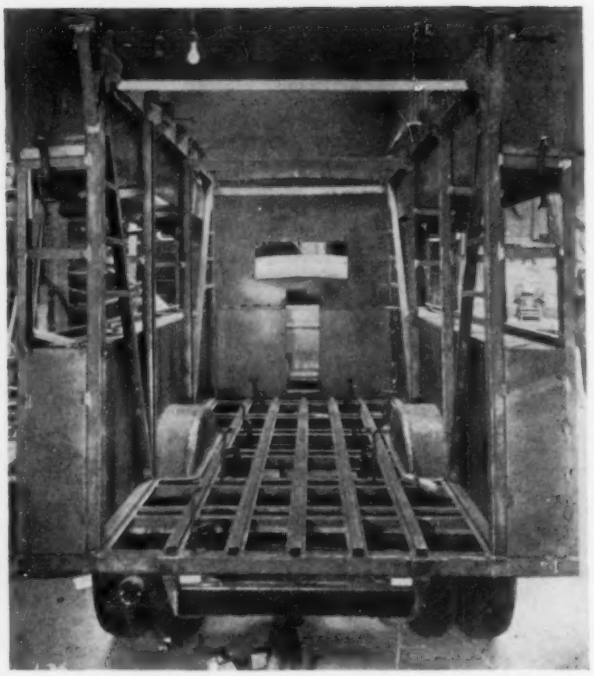


Fig. 2—Diagonal Braces Stiffened with Struts Between Diagonal Braces

member the posts in this system are fitted and securely welded into the cross members by continuous bead arc welds. These posts are box section formed from sheet as channels with closure strips welded between the outer edges of the channel flanges with continuous bead arc welds for the full height of these posts. From their junction with the cross members these posts extend vertically to the inside of the top rails and are arc welded with continuous beads, one bead at each of the free edges of the channel post flanges, along the flanges at top of cross members, down the post on each outer corner of channel posts inside the cross member and across the back of channel post inside the cross member. The box section posts are similarly welded with continuous bead arc weld inside the cross member and across at the base and across the width of the post at the cross member at each side. All four posts are welded inside the top rail. After posts have been welded to top rail, soffit strips are fitted to the inside of the top rails in the spaces between adjacent posts. These soffit strips are arc welded with continuous beads along both flanges of the "U" section top rail.

Between posts are diagonal braces stiffened with struts between these diagonal braces. All of these diagonals with their bracing struts show in Fig. 2.

At the outer ends of cross members are 16 gage plates formed as channels with narrow flanges extending upward which form the bottoms of the lower row of material bins which together with the rear wheel housing arch combine to form the basic longitudinal strength members of the body construction. These bin bottoms and wheel housing arches are continuously welded where they join the cross members previously referred to. The inside systems of body post diagonal braces, bin bottoms, inside and outside bin walls and tops and the top rails combine to form approximate trusses along the outside at right-hand and left-hand sides of the body. Between cross members and the rear axle, drawer slide angles are tack welded to these members which accommodate two shallow tool drawers which slide below the underside of the floor of the bulk loading space. These drawers are intended for carrying flat tools, such as handsaws, one-man cross-cut saws and small tools such as chisels, auger bits, stone drills, etc., which can be accommodated in drawers of this shallow depth. Another function of these drawers is for carrying standard rubber line hose. Ahead of the rear axle is another shallow drawer but made wide enough to accommodate a two-man cross-cut saw of five-foot length. It has the same depth as the two previously described drawers.

Referring to Fig. 3 which shows a more advanced state of completion of the body there may be seen the slots in the body side wall to accommodate the drawers just described. There is a series of three stowage compartments below the body floor, winch and cab floors accessible through three doors.

The construction of the compartments, side walls and bottom form a structural tie between the front of the cab and the body proper where it would be otherwise cut in two by the winch frame. The intention of this design is to make the winch accessible on occasion when major repairs are required on the winch. The winch was mounted in the shop of the winch manufacturer before constructing the body.

The method of anchoring the body to the chassis is considerably more rugged and safer than the method generally employed for attaching custom-built bodies to truck chassis. The principal reason is that in this form of attachment the holding bolt at each anchor is in shear and the whole combination has a minimum weight and stiffens cross members at their points of support on the chassis frame. The fastening bolts are all placed on a line of the neutral axis of the truck frame side channels and do not have a tendency to weaken

Fig. 3—More Advanced State of Completion of the Body

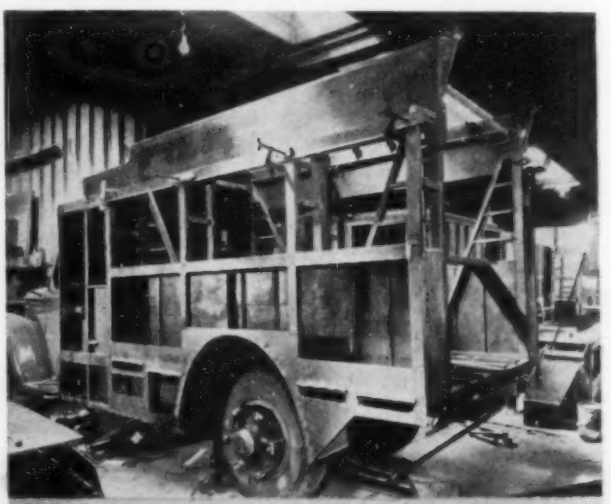


Fig. 4—Truck Showing Slight Difference in the Construction of the Rear Outside Body Cross Member

these frame members as the tension of typical double bolt or "U" bolt body anchorages would have, due to the fact that the latter method of attaching bodies to truck frames puts the fastening bolts in tension, and when this occurs such bolts are liable to be drawn up tight enough to buckle the channel frame sills which would naturally weaken these members.

Referring to Fig. 4, there will be noted a slight difference in the construction of the rear outside body cross member. This item is the heaviest single unit member of the whole body construction. It is formed of No. 10 sheet; and, inasmuch as two bodies only were under contract, it would have been uneconomical to build special die equipment for press forming this member. Consequently it was laid out and the sheet trimmed to shape; cuts were made where the lower flange inclines from the full depth at the center section to the outer ends. The forming was done by using a hydraulic wheel press for which power brake dies were made by the contractor's shop on other work preceding this construction.

Realizing that the unforeseen has a way of happening when least expected, we decided that if for any reason a truck was tipped over, the most usual side on which it would lie after being tipped over along a road would be the right-hand side and regardless of the fact that other designs have windows in the crew cab on the left-hand side, this did not afford as free escape from the tipped-over truck as a door would have, made exactly like the one on the right-hand side; so this body was designed with doors on both right- and left-hand sides and both alike.

This truck unit is provided with a pole derrick which is a simple gin pole made of selected yellow fir, clear spar stock, and turned to the conventional curved taper, commonly used on ship spars. The upper end is slotted for the head sheave of the gin pole and a strap covers the sides of the upper end, while in the sheave slot opening wearing plates at the pin hole for the sheave are provided. An anchorage is provided just below the sheave slot for the four guys which support the pole when it is raised. Referring to Fig. 5, the gin pole may be seen in the position in which it is carried while the truck is on the road.

The gin pole is supported at the rear of the truck for carrying only on the spindle shaft which is a secondary function of this shaft, and when the pole is set up as shown in Fig. 6 the foot of the pole rests on the center of the loading space floor at its rear and where the load is taken and is transmitted to the ground through the heavy rear outside body cross member to the stiff legs.

The body-loading space is covered with a canvas roof which is carried by the top bows previously described. This canvas roof is held along its two sides and the front end by fasteners and the rear edge is attached to the rear top bow by means of leather straps.

The unit was prepared for use in urban and rural line construction service in a neighboring state where the gross load rating is the basis of determining the cost of licensing trucks. For a truck weighing and rated at 15,000 gross the annual fee in addition to the regular license fee of $3.00 is $18.00, but for a truck weighing 20,000 pounds gross the additional fee is $45.00, making a difference of $27.00 per year.

The company operating this truck follows a policy of using its trucks for a minimum of ten years. This term can be considered here as the useful life of the vehicle.

Considered on this practical life basis we compute interest at the rate of 6% a year for ten years on the cash saving of $650.84 and we find that the annual interest is $33.05, whereas for a ten-year period it is $330.50 and the sum of principal and interest $981.34. If we apply interest to the license saving at the same annual rate, the first year's savings would be computed and accumulated for ten years, similarly the second year's savings would be computed and accumulated for nine years and the third year for eight years and so on until the last year for one year. Computed by this method for ten years the interest on $27.00 per year for ten years would be $89.12, making the total of principal and interest $359.12, and adding the two gross items of $981.34 and $359.12 shows a gross of $1400.44.

In addition to this saving which is one of the benefits resulting from the use of a body of this design, a comparison of cost of this unit and the one which it replaces and which was purchased and placed in service in 1928, the company's records show that this earlier unit cost $6439.00, and the new unit equipped with this latest body design shows a total invoiced cost of $3380.69 to which is added $600.00 as design and inspection cost, making a total of $3980.69. The difference in the cost of the two is $2458.31.

Fig. 5—Gin Pole in Position in Which It Is Carried While Truck Is on Road

Fig. 6—Gin Pole Set Up With the Foot Resting on the Center of the Loading Space Floor at Its Rear

DESIGN OF WELDED RIGID FRAMES

By MARTIN P. KORN*

WITHIN recent years the subject of continuity has attracted the interest of many engineers. Already a number of continuous girder and beam spans have been built. Economies effected are making for their wide and general acclaim. Even greater economies are being sought with rigid frames. Economy through continuity seems destined to command the future.

Naturally the structures that ushered in this new era in design were riveted. For rivets exist enshrined in the skies. Towering structures stand stalwart as testimonials to their safety. There must be safety.

Though savings were thus effected through better design, those "new era" structures were joined in almost the same fashion as the original models. The original models had excess steel for connections. The latest ones do. Extra weight for connections has thus continued to pile up unabated since the beginning. Paradoxically this new design for economy more than ever increased this cumulus of inert steel.

Metals used only for connections if piled up through the sweep of the steel age would have made mountains of excess weight. Science marched all around that excess weight made necessary by riveted connections, it improved everything else. Rivets defied the march of time. They carried their necessary burden defiantly through time. Those excess burdens hung on inert through sheer necessity. Science could not eliminate those burdens without eliminating the very process of riveting.

With rivets as it was in the beginning so it is today.

Welding fully tested and tried now presents to continuity new frontiers. It is synonymous with continuity. It makes possible new economies not attainable by the riveting process by giving continuity with practically no excess metals for connections. In rigid frames it attains its fullest advantages. For the benefit of progressive and pioneering engineers who had been raised on rivets, the design of welded rigid frames will be outlined.

The procedure is as follows:

(1) Selection of type of frame.
(2) Preliminary design.
(3) Analysis of design for fabrication and erection.
(4) Analysis of stresses.
(5) Design of welded joints.
(6) Specifications, etc.

This procedure is given only to stress the importance of operation 3 as a functional part of welded design. In practice operations numbered 1, 2 and 3 become a single operation.

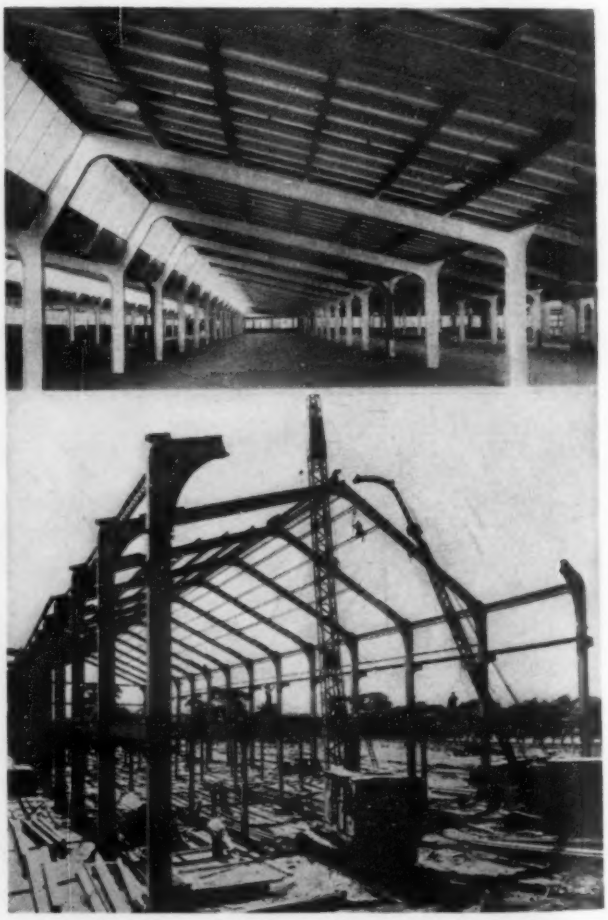
To attain welding's fullest economy over riveting, the type selected must not follow riveted patterns. It must be distinctly a "Welded Design," not one that is convertible from riveting. Full consideration of operation 3 is necessary to make it a welded design. The new work it entails is simple and easy to learn.

*Consulting Engineer.

SELECTION OF TYPE OF FRAME

Welding and its adjuncts in modern flame-cutting apparatus permit of any type of plastic pattern in steel. Fusion can be attained without end. Rigid frames can be patterned as desired. This advantage becomes, however, a disadvantage when it comes to the analysis of stresses. For welding's unlimited possibilities must need stop at the boundary line of known methods for design.

The few riveted rigid frames that have already been built evolved gently from the patterns that have proved themselves through the life of the steel age. Photo herewith of West Side Improvement, New York City, attests that fact. But patterns in welded rigid frames do not evolve. They flower in the "mind's eternal heaven where dreams are begot." Observe, for example, some welded frames conceived and actually built within the past few years, as shown in accompanying photographs of New Lincoln Electric Company plant. Figure 1 indicates in outline several other types. Plainly they bespeak a new concept in design not evolved of the past. Their sweeping grace might easily forebode Surrealism



Welded Frames at the Plant of The Lincoln Electric Co.

in welded rigid frames but for the fact that each new pattern becomes at once a new problem child in design because of its knees. For practically nothing is known about the stresses in knees made of structural steel. That holds also for riveted rigid frames. But with them the problem is not so acute for they are not so likely as welded rigid frames to step out and reach for the stars. A ceiling on design of welded rigid frames therefore becomes necessary for safety.

As knees vary in form, so vary the paths for their stresses, their shears, their concentrations of stresses. In most cases also the center of gravity of knee section does not coincide with its neutral axis. That makes necessary variable theorems for the calculation of their stresses. Design of type shown in Fig. 2 is, for example, different from that of Fig. 3. In some cases no stress results in outer corner, particularly where its angle as in Fig. 2 is less than 90 degrees. That can be almost visualized from observation. Racing around the sharp inner corner, the compression stresses "gang up" there in a small concentrated area through added pressure from knee (double compression). The tension stresses having to cover a greater distance on the outside in the same time naturally tend to cut the corners and pass through the web. The unlimited variation possible in keen patterns consequently makes for unlimited theories for their design. From a practical standpoint such patterns can be restricted to a few types adaptable to various requirements and to the slide rule. Investigations conducted by the author theoretically and experimentally will be limited here to discussion of selected types for which he has established theories for design of knees.

A fundamental general principle of welded design insuring the greatest economy in costs is to limit all welding as much as possible to the knees and bent joints of frames—using rolled beams for the remaining members. This precept should be given primary consideration in the selection of a type of frame. Comparison of several different types should make for its understanding.

Figure 4 represents a rugged frame made up of separate plates and stiffeners welded continuously. Considerable steel in web plates is cut out and probably scrapped. Four lines of continuous fillet welds are required for full height and width of frame. Unnecessary costs result here due to fitting, steel scrap, cost of welding and weld material. This type does not develop welding's fullest economy.

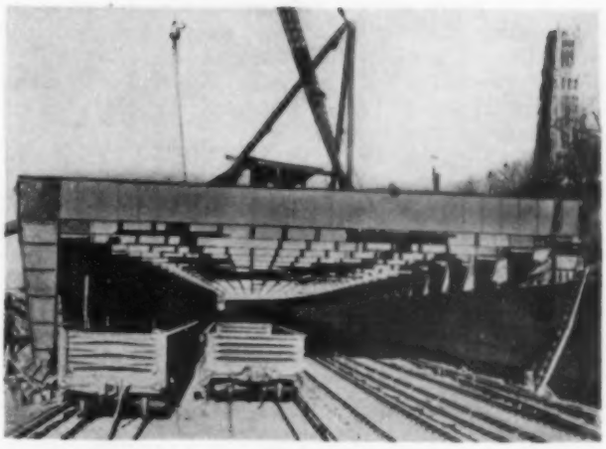
Figure 5 illustrates one way to eliminate practically all waste steel and almost half of the welding material and labor if you particularly desire that type of frame. Two pieces are cut from one beam as shown in Fig. 6 and the shape of the frame is modified to permit of the efficacious use of such pieces. The reduction of direct labor costs, as in this case, always means an additional savings in indirect costs—shop overhead.

The most economical type would employ rolled beam sections throughout, except for built-up knees.

Before any design is adopted that requires continuous welds throughout the frame, a study should be made to eliminate such welds by the substitution of rolled sections or pieces cut from them. A little ingenuity here will frequently make for master savings.

Figures 7*a* and 7*b* illustrate simple types of welded rigid frames suitable for assembly halls, schools, etc., and adaptable with slight modification to almost any purpose. Even the knees can utilize pieces cut from rolled sections in the manner previously explained. These types employ plates at all joints.

Figure 8*a* identical to 7*a* is suitable for very wide spans. Smaller beams can be used toward center for smaller moments. Connection between sections of varying depth is accomplished as in Fig. 8*b*. Triangular pieces of web are cut out at top or bottom flange and then flange is bent in and welded. Figure 8*c* shows another form of connection. That eliminates cutting of web as in Fig. 8*b* and while it requires a little more welding, it saves in time and operations.



Riveted Steel Rigid Frames—West Side Improvement, New York City

Figure 9 is a modified type of Fig. 7*a* employing butt-welded joints throughout.

Note employment of rolled beams in Figs. 7, 8 and 9 except for knees which are built up.

Type in Fig. 9 makes for somewhat better appearance than types 7 and 8. The butt-welded joints require shop preparation of all edges. The cutting of knee web plates is done individually for small jobs, putting them in the "tailor-made" class with resultant higher costs of labor and overhead. Curved outline of knee in single web plate makes for waste steel. For a design of magnitude such plates can be cut in quantity in a single operation by automatic cutting apparatus at very low costs. Waste steel here is, however, increased in quantity. Shop fitting in jigs must be extremely accurate for butt-welded joints to avoid misfit of field joints. Flange plates of knees must be bent.

Above type can be fabricated also by cutting inner flange of column, bending it to desired form, inserting and welding additional piece of web plate—an operation which is costly and unwarranted.

Comparing types 7, 8 and 9, types 7 and 8 employing plates at all joints require preparation only of flanges for joints. More welding material and labor are required. Stiffeners make for small additional weight of steel. As against this, the bending of plates and the re-entrant cuts are eliminated. All waste steel common to Fig. 9 is eliminated as webs of knees are formed of separate plates welded to stiffeners. The stiffeners and milled edges of beams automatically make for correct shop joints without undue fitting and for better field joints. Their fabrication is economical for the smallest as for the largest jobs. The smallest shops can fabricate it. The joints are stronger against buckling, heavy loadings and impacts.

In general the employment of angular design in a welded rigid frame as in Figs. 7 and 8 makes for greater rigidity and strength, simpler fabrication and erection and slightly lower costs.

Figure 10 represents a type of frame that does not develop welding's fullest economies. Where inside faces of knee make right angles they do not make for economical routing of stresses. They increase moments throughout frame and consequently require more steel. The very shape of knee induces heavy concentrations of

stresses at inner corner with practically no stress at outer corner, making for a most unbalanced design of knee. Obtuse angles both inside and outside as in Figs. 7, 8 and 9 make for lesser concentrations and more direct routing of stresses at knees, decreased moments in frame with commensurate economy.

Figure 11 represents a type of rigid frame employing beams without change in sections at knees—only the webs and flanges reinforced. It is not economical. Greater depth at knee than in contiguous members is fundamental for economical design.

Consider now a case representing the other extreme of "too much knee" as in Fig. 12. You might consider it too much for type having square corner when dimension "x" is larger than $2^1/_2$ times width of largest contiguous member. In this case the outside corner carries no stress as previously mentioned. Flange plates are consequently not working where needed. Tapering of outside lines as in Fig. 13 makes for a simpler, stronger and more economical design.

Figure 14 represents a joint for multiple spans employing all rolled sections throughout with the minimum of welding labor, material and fabricating operations.

It seems fitting to pause here before proceeding further to make note of other fundamentals in design. Emphasis was previously placed on the importance of limiting all welding as much as possible to the knees and bent joints for economy. To that must be added the fact that the patterns and sizes of knees are vital factors affecting definitely the economical weights of the members in the frame proper because of their effect on the moments. Particularly is that true for short spans with heavy loadings.

The selection of a type of frame therefore involves not only limiting your welding to those knees but also shaping those knees to such form and to such dimensions that the remaining members be of the lightest sections.

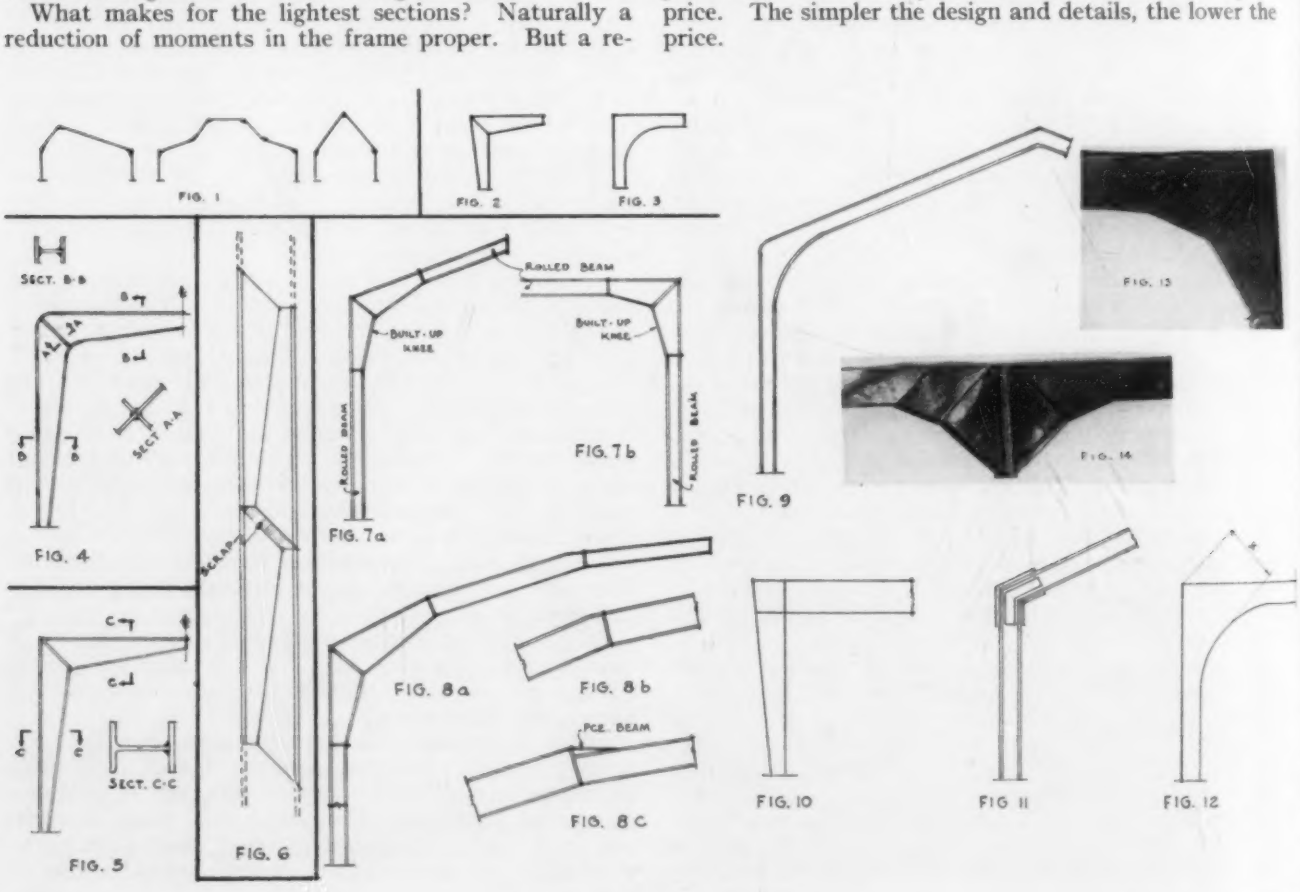
What makes for the lightest sections? Naturally a reduction of moments in the frame proper. But a reduction of moments in the frame proper makes for heavy duty by the knees. Wherefore we can truly conclude that the greater the amount of work assigned to the knees, the less steel will the remainder of the frame require. (This should not be construed as meaning the largest size.) If, now, this theorum be accepted as true, the question might be asked, "Why not first design the knees and then design the frame around them for the greatest economy?" The answer to that is that it is not at all impossible or unsound. In fact, it might be stated that that procedure alone makes for the most economical design for some types of frames where large quantities are involved. (This will be covered in later papers.) When it is realized that the knees act as "traffic centers" directing the stresses in the entire frame and affecting their behavior, their importance will be properly considered in the selection of a type of frame.

The types presented so far have been limited mostly to frames of simple spans. In general their principles for economical design apply equally to frames of multiple spans except that the calculation of stresses in knees between adjacent spans is different than for those at corners. We will confine ourselves first to understanding the stress behavior in single spans.

ANALYSIS OF DESIGN FOR SHOP FABRICATION

As stated previously this operation cannot be separated in practice from the preceding studies. The designer who thinks in terms of rigid frames must be a visionary type. Having, therefore, the talent for projected views, he should visualize fabrication and erection of his structure as his preliminary designs take form in varying outlines.

The fabricator's estimates are based upon your details. For they alone determine the unit costs on your job. The more exact your details, the more exact your price. The simpler the design and details, the lower the price.



Duplication of pieces, particularly those cut to special shapes, should be planned even if in some cases it means the use of additional steel. Details should be standardized or made alike. Think in terms of quantity of pieces and make their joints consistent with best practice. Visualize also those operations that make for their fabrication and reduce their variety to a minimum by planning your design to suit. Do not use every possible size of fillet weld. Limit that to the minimum. Straight cuts should be given preference to curved or re-entrant cuts. Field welding should be reduced to a minimum. Overhead field welding should be eliminated except where absolutely necessary. Specifications should follow the accepted practice and they should be elastic enough to permit fabricator or contractor to substitute his own if they be as effective for the desired results.

Comb final design for small corners and other details that look innocent on the drawing board but cost plenty. For it is on the details that the contractor estimates his total costs, not on the mere rolled sections or cut lengths whose prices he knows to the third decimal point.

We have now covered a number of points describing, in general, operations that make for economical fabrication. A good welding handbook plus a little experience will do more than a ton of words to reduce to habit the matter of judicial consideration of fabricating costs. It is simple.

ANALYSIS OF STRESSES

Since the advent of the "Hardy Cross" method, other methods have been promulgated aiming for the same end —the elimination of the hard labor in the computation of stresses in indeterminate structures. Says a recent editorial in the *Engineering News-Record*, "Indeterminate structures are now used more often than they are avoided." That, in brief, tells the story of the effect of those new simplified methods. It also summarizes the trend of the times. Abundant literature on the subject is now available everywhere. Some is being distributed nationally without charge. Analysis of stresses in these papers will therefore be limited solely to those involving the design of knees.

DESIGN OF WELDED JOINTS

This operation resolves itself to arithmetic for the calculations and your welding handbook for reference. In quick time that book will function as have handbooks for riveted joints. To begin with, confidence in welding is necessary for the execution of a good design. For the amount of your confidence is plainly reflected in the fabric of your design. It is not expected that the average engineer who was raised on rivets will take easily to welded joints. The pioneering engineer who goes in for indeterminate structures is more likely, however, to focus both eyes ahead instead of behind. If you want the most economical rigid frames for your design, weld. But if you feel like the engineer who wrote in a recent copy of the A. S. C. E. Proceedings, "Welds have not yet demonstrated completely that they are as reliable as rivets," do not weld.

Should you elect to see what you can see, you may probably come to feel as does Prof. J. A. Van den Broek who wrote in the A. S. C. E. Proceedings for February 1939, "Rivet connections appear to be 'giving ground' to welded joints. It may be hoped that they soon will disappear entirely."

Incidentally this was his only reference to welding in an article not otherwise related to the subject. Plainly the learned professor manifests full confidence in welded joints when he expresses that sort of wish. It is safe to assume that his statement is born of actual knowledge.

The question of the strength of welded joints no longer forms a party line between engineers who weld and those who do not weld. It is now a matter of fact and living record. Examine for yourself some that are now doing heavy duty. And do not take along any one who might possibly try to sell you the idea of using welding. Carry only a few rivets and a punched connection angle for quiet meditation.

Welding materials have been so highly developed and improved that you can now know in advance what to expect from any recognized brand. Manufacturers' enthusiasm does not sell their products, only joints that live by their products. Equally proficient have become the leading fabricators and welding contractors who follow the established codes. They—your tools and workers at welding—assure safety through qualification tests. No welded rigid frame that is properly designed and executed will fail in its welded joints.

SUMMARY

From an investigation covering research and experimentation over a period of many years, information in the preceding pages has been culled. The impossibility of attempting to outline within the scope of one article or even several articles that vast work becomes apparent. However, consideration of the points outlined and to be continued will, it is hoped, make for a better approach to the design of welded rigid frames. The hope is also expressed that they will serve to stimulate interest and further investigation by others. The best effort already made to that end was initiated by the American Institute of Steel Construction upon recommendation of its Chief Engineer, F. H. Frankland, in collaboration with the U. S. Bureau of Standards. Certainly no institutions anywhere are better qualified and equipped to conduct such work. It is hoped that the combined support of all engineers throughout the country and all technical societies will make possible their uninterrupted continuation of that work which presages new economies never before attained.

The calculation of stresses in rigid frames has now been reduced to every-day pleasure. Their auspicious start with riveted frames paves the way to their future development with welding. For indications now point to welding as the process tending to shape for structural steel a new destiny. It is safe to conclude that in the near future engineers will treat the subject of welded rigid frames with the same equanimity of mind as they now design structures of simple spans.

ACKNOWLEDGMENTS

Most grateful thanks are hereby expressed to John Wm. Morgan, Registered Engineer, Pittsburgh, whose assistance in stress analysis of indeterminate structures proved of inestimable value in this work. Thanks are also expressed to E. W. P. Smith, Consulting Engineer, Lincoln Electric Co., Cleveland, to the Stanley Wood Co., Welding Contractors, Sandusky, for their welded structural specimens, to William B. Spurrier of Detroit, and Prof. L. C. Maugh, University of Michigan, for their suggestions on celluloid models, to Robert Siemer of Allen Welding & Mfg. Co., Buffalo, and many others not listed here who have so kindly contributed with their advice and assistance.

FLASH WELDING ALLOY STEEL

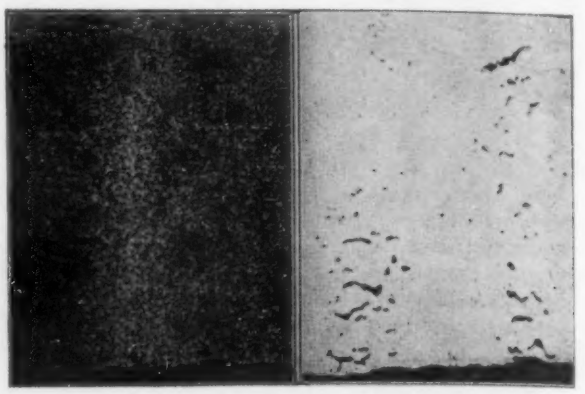
Tubes*

By WILHELM DENKER

IT IS well known[1] that there are three stages in flash welding: preheating, flashing and upsetting. Whereas the first step merely heats the metal, flashing superheats and cleans the preheated surfaces. Immediately following flashing, the current is switched off and the surfaces to be welded are pushed together; that is, upset.

After the current is switched on, the surfaces to be welded are brought into contact and short circuiting occurs. Through a series of short circuits the surfaces attain a high temperature. If the current is switched off it will be observed that small particles of superheated metal continue to fly from the heated surfaces on account of both the high concentration of heat in the surfaces and the slow conduction of heat to the adjacent preheated zones. Both conditions lead to the local formation of metallic vapor which, upon being evolved under high pressure, blows small particles of liquid metal from the surface. During flashing the mechanism is continuous and the preheated ends are moved toward each other. The slightest contact is a short circuit. The low contact pressure localizes the heat evolved to the surfaces to be welded. The surfaces become fluid and a current bridge is formed whose shape is determined by surface tension. In its narrowest section the bridge is so highly heated that vapor is formed and the bridge is ruptured. The formation and rupture of bridges occurs many times during flashing.[2]

Rietsch[3] states that the metal vapor acts to protect the surfaces to be welded from air and oxidation. The protective action is exerted in solid cross sections, to be sure, but in the welding of hollow sections, such as tubes, the heat tends to increase the pressure within the tubes. Before the tubes are welded the pressure is equalized through the gap at the surfaces to be welded. In plain carbon steels whose component elements have no greater affinity for oxygen than iron, the danger of oxidation and accompanying defects is slight. Nevertheless, defects due to oxidation sometimes are observed, Fig. 1. The oxide defects, which occur principally if the flashing energy is too high, seem to consist of metal droplets that have been trapped during upset in craters caused by flashing. The liquid droplet is coated with an oxide film which prevents welding with the flashed surface. If the droplet lodged near the edges of the tube, doubtless it would be forced from the weld during upset.



Figs. 2 and 3—Hot Cracks Adjacent to a Flash Weld in Chromium-Molybdenum Steel

To repeat, oxide defects seldom appear in flash welds in unalloyed steels made under correct conditions. Excessive energy and insufficient flashed length favor oxide defects, because the surfaces to be welded lose heat too rapidly to the insufficiently preheated adjacent zones and the weld is made "cold."

Until very recently there was no quantitative information on the upset pressure required in flash welding. Kilger[4] found that the best upset pressure for flash welding mild steel is 4300 lb./in.^{2} Subsequent investigation has confirmed Kilger's results for steel with 0.10 C but for higher carbon steel (0.45 C) the upset pressure must be decreased. As the carbon content increases the range of temperature between liquidus and solidus is larger, and welding is possible so long as the temperature at the weld is above the solidus, that is, the upset pressure decreases as the solidus temperature is lowered. The upset pressure for flash welding alloy steels may be gaged from the effect of the alloying elements on the solidus. Elements that increase the viscosity of the melt, increase the upset pressure.

Numerous investigations have shown that the flash

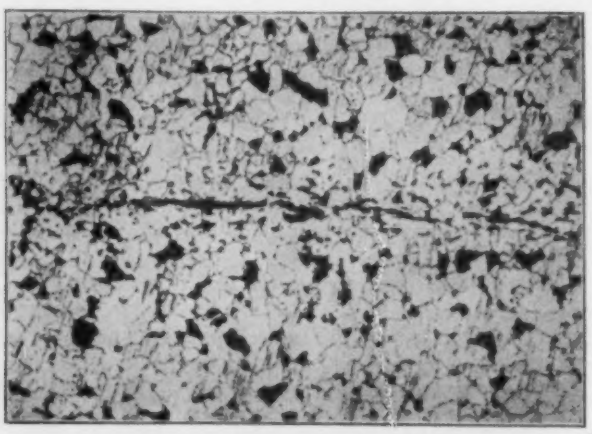


Fig. 1—Oxide Inclusion in Flash-Welded Steel

* Translation of Abschmelzschweissung von legierten Stahlrohren, published in *Stahl und Eisen*, **59**, No. 13, 396–398 March 30, 1939. Presented at a meeting of the Subcommittee on Weldability of the German Society for Ferrous Metallurgy, Dec. 12, 1938. Translated by Dr. G. E. Claussen.

[1] See Schimpke, P., and H. A. Horn, *Praktisches Handbuch der gesamten Schweisstechnik*, Third Edition, Berlin, 1938.

[2] Kilger, H., *Elektroschweissung*, **8**, 4–8 (1937); Rietsch, E., *Masch.-Bau Betrieb*, **16**, 25–28 (1937).

[3] Rietsch, E., *Elektroschweissg.*, **8**, 41–43 (1937).

[4] Fertigungstechnik und Güte abbrenngeschweisster Verbindungen. Braunschweig, 1936.

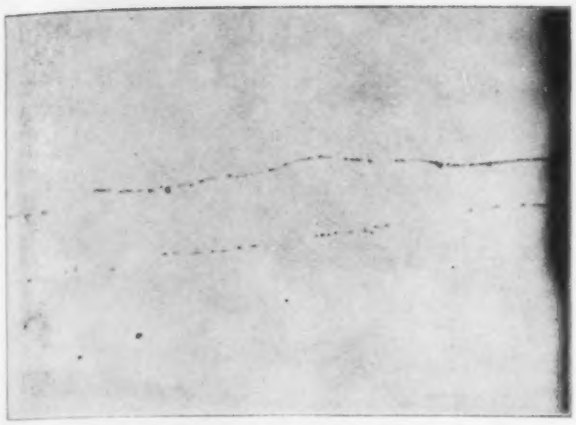


Fig. 4—Section Through a Flash Weld in a Chromium-Molybdenum Steel Tube Showing Inclusions of Chromium Oxide

welding of the alloy steels used in boilers and chemical apparatus depends principally on upset pressure and upset velocity. The upset pressure for the alloy steels should not fall below the limit for plain carbon steels. Increasing the upset pressure 100% above the maximum pressure for plain carbon steel is not disadvantageous. Exact regulation of upset pressure is feasible only in automatic or semi-automatic machines. Manual flash welding must rely upon the judgment of the operator.

The transformers of flash welding machines have numerous taps permitting current adjustment in relatively small steps. In this way any cross section within the capacity of the machine can be welded at the correct current. Whereas excessive energy leads to "cold" welding, insufficient energy increases the welding time and overheats the weld and the zones adjacent to it. It is possible to squeeze the overheated metal from the weld by means of high upset pressure. However, the upset then is so large, especially in tubes, that the flash cannot be broken loose on the inside of the tube.

If the upset pressure is low or at the lower limit, intergranular hot cracking may occur in the overheated zone adjacent to the weld. Figures 2 and 3 show welds in chromium-molybdenum steel in which the weld metal is clean and free from cracks, but the heat-affected zone contains intergranular cracks. Heat treatment refines the grain structure, but does not eliminate the cracks. Hot cracks may occur in any flash-welded steel. Overheating and inadequate upset pressure may lead to the propagation of cracks throughout the cross section. Under more favorable circumstances the cracks may be confined to a small region in the joint.

The existence of hot cracks can be demonstrated only by destructive tests. In bend tests fracture occurs close to the weld at a small bend angle. The fracture has a dead appearance. In tension tests the full tensile strength of the steel usually is developed, yet the fracture is brittle with very low elongation. Metallographic examination is the safest means to detect the hot cracks. No service failures due to hot cracks have been reported.

Flash welding is so free from difficulties that little progress has been made in testing, although flash-welded alloy steels free from hydrogen embrittlement are used, for example, in benzine synthesis at 11,000 lb./in.,[2] 500° C. Flash welds in steel containing about 0.2 C, 1.0 Cr, especially if made in manually operated machines, frequently contain cracks. These cracks, which are due to "cold" welding, are revealed in the microstructure, Fig. 4, as double lines of chromium oxide inclusions. Although welds made on automatic machines exhibit the lines to a less extent, the inclusions are present. They are revealed as thin, dark streaks in the automatic welds only by polishing and etching. The high upset pressure has compressed the inclusions. The fractured surfaces of the welds contain chromium oxide. The shape of the inclusions suggests that oxidation has proceeded from the inner surface of the tube to the outer, in accordance with the pressure that is created within tubes during flash welding. Therefore, the welding should be performed in a protective atmosphere. Czternasty[5] has reported results with small chromium-molybdenum steel boiler tubes flash welded in a protective atmosphere. Later investigations show that chromium oxide inclusion do not appear in flash welds made in a protective gas. Aside from a few tiny pores, the flash welds made in a protective gas have the same ductility as unwelded material. Bend specimens of flash-welded and heat-treated tubes containing 0.20 C, 0.6 Mo, 0.5 W, 3 Cr were bent 180° flat without failure. The welded tube (4.0 inches diameter, 0.53-inch wall) was cut into strips 1 inch wide and bent over a pin 1.05 inches diameter. Since there is no difference in structure between weld and unaffected steel after air quenching, the joint is satisfactory for the most severe service.

Flash welding on automatic machines with optimum settings is preferable to arc welding.

SUMMARY

Alloy steels must be flash welded with higher upset pressures than plain carbon steels. The air pressure inside the tube during welding leads, to oxidation, particularly of chromium, and to defective welding. Flash welding in a protective atmosphere prevents oxidation of alloying constituents and permits the satisfactory flash welding of alloy steel tubes.

[5] Czternasty, G., *Autog. Metallb.*, **30**, 337–346 (1937).

Annual Meeting Program

The Annual Meeting of the AMERICAN WELDING SOCIETY will be held in Chicago during the week of October 22nd in conjunction with the National Metals Exposition. The National Program Committee has arranged sessions on the following subjects: Welding in Construction Work, Industrial Research, Production Welding in Light Gauge Material, Fundamental Research, Machinery Construction, Welding in General Construction, Flame Hardening and Hard Surfacing, Resistance Welding, Welded Piping, Pressure Vessels and Boilers, Cutting and Welding in Steel Mills, Welding in Structural and Ship Work, Railroad Session and a Miscellaneous Session.

Altogether some sixty papers will be presented.

Indications are that more than a thousand welding engineers will attend the various technical sessions of the Society. No one can afford to miss this opportunity.

Welding Society ACTIVITIES — Related Events

A MESSAGE FROM OUR PRESIDENT

There have been many milestones of progress in the twenty years of the life of the AMERICAN WELDING SOCIETY. Another was reached on April 27th in the action of the Executive Committee authorizing the employment of an Assistant Technical Secretary.

This step was not made hastily. It has been brewing for some time. Many of the Board of Directors have recognized and believed that the technical work of the Society must advance to keep in step with its growing membership, its increased number of Sections, its enlarged Journal and its effective research program.

Last October, the Board of Directors adopted the policy of running the Society to keep within an income derived from membership dues and Journal advertising. This it has done. At the same time, it decided to obtain for Mr. Spraragen a technical assistant, as soon as reasonably possible—his salary and expenses to come from increased advertising. At the April meeting of the Executive Committee it was reported that sufficient advertising was obtained or in sight, to finance a technical assistant for the rest of the Society year.

It was explained to the Executive Committee that the Society could continue to operate as it has in the past, doing really effective work along technical lines, but that the pace could not be materially increased with the present staff. On the other hand, a new assistant would offer opportunity for additional services. The Executive Committee were unanimous in their desire to move the Society forward and authorized the immediate employment of a technical assistant.

As a result, it is now a pleasure to report that, after six months of effort which was at times discouraging, Mr. Spraragen will on June 1st have an assistant in the person of Mr. L. M. Dalcher, son of John T. Dalcher, a member of the Society. Young Mr. Dalcher will begin his services with a course on training in practical welding. He enters the Society headquarters staff fully aware that the potentialities of his position depend almost entirely on himself. He may be assured of the whole hearted support and good wishes of the Society.

Respectfully submitted,
H. C. BOARDMAN, President

CONVENTION COMMITTEE REPORTS

Mr. C. A. McCune, Chairman of the Convention Committee reported at the last meeting of the Executive Committee that satisfactory progress is being made in making the convention the largest in the history of the Society. The Chicago group has appointed a number of local subcommittee chairmen, consisting of the following:

Reception	R. E. McFarland
Registration	A. M. Candy
Technical Sessions	L. S. McPhee
Exhibits	O. L. Howland
Publicity	R. S. Kenrick
Entertainment	H. S. Goodwin
Finance	M. S. Hendricks
Society Booth	R. S. Kenrick
Inspection Tours	G. E. Tenney
Supervisors Committee	L. S. McPhee

Mr. McCune met with the Committee in Chicago on April 4th. It is proposed to hold another meeting of the Local Arrangements Committee in Chicago about the middle of June, at which time it is hoped to have every member of the National Convention Committee present to discuss in detail all matters pertaining to technical program, exhibits and publicity. Headquarters of the Society will be at the Stevens Hotel. Arrangements for buses to run from the Hotel to the Exhibit Hall at frequent periods, beginning at about 11:00 A.M. and continuing until 2:00 P.M., and again in the evening, have been made. The price of transportation will be 25¢ per person.

MEMBERSHIP GROWING

In its regular monthly report to the Executive Committee, the Membership Committee reported that the number of members were the highest in the history of the Society—the total as of March 31st being 3773. A net of 24 members were added during the month. The Society has at the present time 90 Sustaining Members, 1128 Members, 1619 Associate Members, 846 Operating Members, 71 Student Members and 1 Honorary Member.

FINANCES OF THE SOCIETY IN GOOD SHAPE

Treasurer C. A. McCune reported at the Executive Committee meeting on April 27th, that the finances of the Society are in excellent shape. A profit of $698.45 for the first six months of the fiscal year ending March 31st, was reported above budget estimates. Mr. McCune stated that the principal item of expense in excess of the budget was the JOURNAL but that this expense was fully warranted.

WELDING HANDBOOK COMMITTEE DISCHARGED

At the meeting of the Executive Committee held in New York on April 27th, the Welding Handbook Editorial Committee submitted its final report with the recommendation that it be accepted and the Committee discharged. The report was approved and the Committee discharged with thanks.

Chairman Jacobus pointed out that the primary purpose of issuing a Handbook was to furnish the welding industry with a precise, authoritative reference book and thus render a professional service. It also enabled the AMERICAN WELDING SOCIETY to offer an additional inducement for membership.

Chairman Jacobus reported that the Handbook had been financially successful; all bills having been paid, with a resulting bank balance of several thousand dollars. The Committee submitted with the report a number of recommendations which the present Editorial Committee felt should receive careful consideration in connection with the publication of a second edition of the Handbook, which probably will be undertaken within a few years.

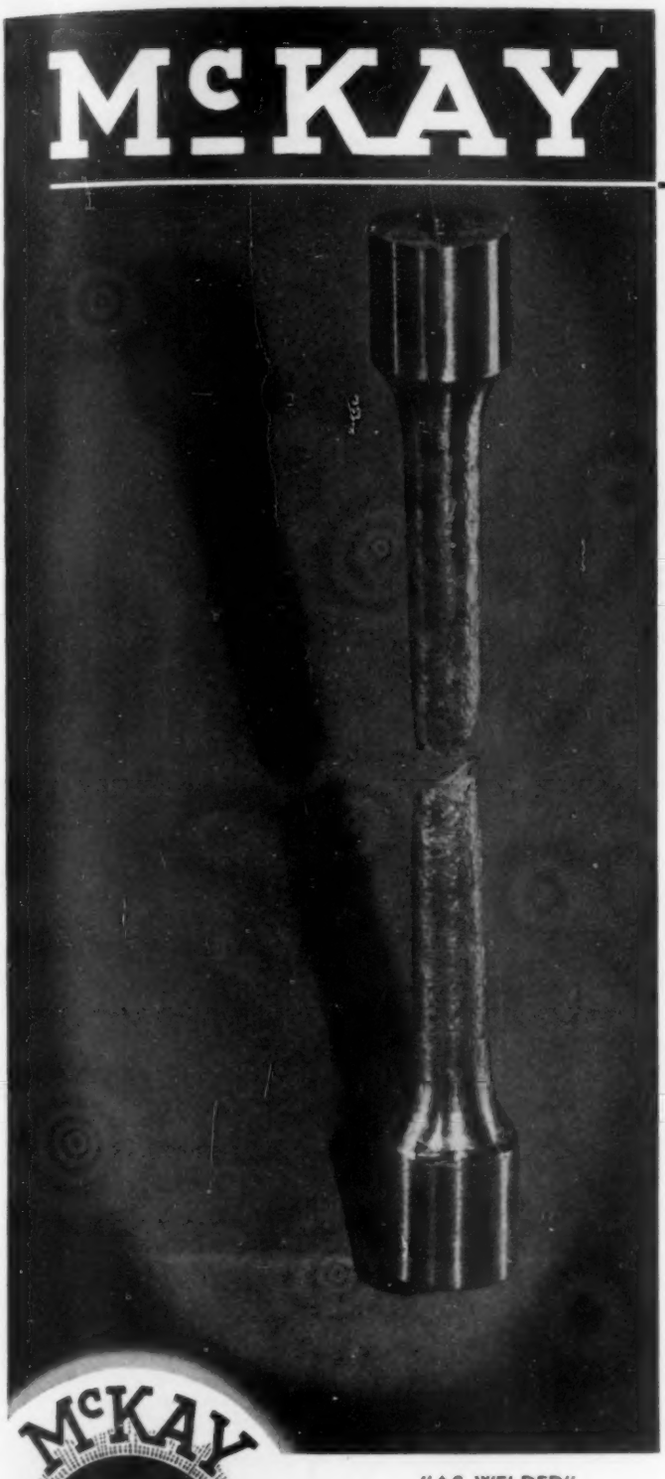
The suggestion of the Editorial Committee that any surplus from the Handbook be set aside in a special reserve fund was well received. Chairman Jacobus pointed out that a limited supply of the book is still available, but at the present rate of sales, the supply of the book would be exhausted within a year.

COMMITTEE ON OUTLINE OF WORK ACTIVITIES

Non-Destructive Tests

The Committee on Outline of Work has recommended the appointment of a Committee on Non-Destructive Tests paralleling the work of the Committee on Standard Tests for Welds. Such Code, if available, would be used by other code making Committees in the Society and by associated bodies. It is felt that this work will supplement the work of other organizations such as the A. S. T. M., A. S. M. E. Boiler Code Committee and the Welding Research Committee. The activities of the Committee are to cover radiographic examinations, magnetic examinations and

McKAY *Certified* STAINLESS *Welds* ARE NEW



McKay Certified Stainless Electrodes are the answer to the demand of industry for uniform high-quality weld deposits. The chemical analysis of the core wire is secondary to the assurance that the *weld deposit* will result in a "balanced alloy" of specified analysis. Each carton of McKay Stainless Electrodes contains a certification of weld-deposit analysis made from a heat of steel of which these electrodes are a part.

Actual welding tests on present-day stainless electrodes prove that the electrode analysis is no criterion of the ultimate weld analysis. For this reason, The McKay Company carefully select entire heats of steel measuring up to certain narrow-range requirements that will compensate for chemical changes during the arc passage.

Specify McKay Certified Stainless Electrodes for uniform high-quality welds of specified analysis.

For further information, write for McKay Stainless Catalog.

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McK STAINLESS ELECTRODES *Certified*

"AS WELDED"
(Illustration above)
All Weld Metal .505" Tensile Test
Welded with McKAY Certified 18–8 Stainless Electrodes

Tensile Strength	88,825 psi
Yield Point	61,700 psi
Elongation in 2 Inches	49%

THE McKAY COMPANY McKAY BLDG., PITTSBURGH, PA. SALES OFFICES . . . YORK, PA.

examinations by drilling into and taking samples from welds.

Committee Personnel to Be Reviewed

The Committee on Outline of Work will shortly send communication to all technical Committee Chairmen requesting reports of progress, of work completed and contemplated.

Standard Tests for Welds

This Committee has recently issued in proof form, a Code for Standard Methods for Mechanical Testing of Welds. Copies of this report were sent to all committees of the Society and other interested bodies soliciting comments. It is the aim of the Committee to publish this report in a form which will be acceptable to every one.

Welding Storage Tanks

The Committee on Outline of Work has recommended the appointment of a Committee on Welding Standards for Tanks for the Storage of Liquids under pressure not to exceed 15 lb. per square inch plus hydrostatic pressure. It is not the intention of this Committee to interfere with the work of existing Code Committees such as, Oil Storage, Elevated Water Storage, Tank Risers and Towers, and the like. The plan is to cover fields not already covered by codes and to promote the use of standards so that existing codes may in time be coordinated.

Code for High Alloy Engineering Structures

The Committee on Outline of Work recommended the appointment of a Committee to prepare a Welding Code on High Alloy Engineering Structures.

GEAR NOISE DAMPED OUT BY WELDED IRON RING

Identical except that one has a thin band of steel welded to the inside rim, two standard gears from a street car will be used to demonstrate the resonance that makes noise and clashing in standard use, and a method of taking up the resonance, in the Westinghouse exhibit at the New York World's Fair.

The Two Standard Bull Gears Mounted on a Table with a Steel Mallet Swinging between Are Exactly Alike, Except That One Has a Steel Ring Welded Loosely Around the Rim of the Gear to Keep It from Vibrating at Its Natural Frequency

When the gear and pinion teeth of a street car drive mesh, the striking of steel against steel makes a loud sound, which the vibration multiplies and holds for several seconds. With the gear turning over rapidly, a new blow is struck as each tooth meshes, keeping up a steady din.

By putting a thin band of steel into the inside rim, welded at only three or four points, the vibration caused by each stroke of the teeth is taken up by the thin band, and the resonance or noise is "damped" out. The ring must be welded to the gear at just the right number of places, neither too few nor too many, else the vibration will not be damped by the ring, or the ring will react equally with the gear.

In the exhibit, the two gears are mounted upright on a triangular stand, with a mallet mounted on a pivot between. Only a dull quick "clink" is heard from a blow on the gear with imbedded ring; a resonant "clang" of several seconds duration results from a stroke on the other gear.

SCULLY STOCK LIST

The Scully Steel Products Company, 1319 Wabansia Ave., Chicago, recently published a new and improved stock list and reference book for 1939. This book is published mainly for greater convenience in ordering material from stock and as such is valued quite highly by customers, as is also the reference section of this publication. There is a section on Welding.

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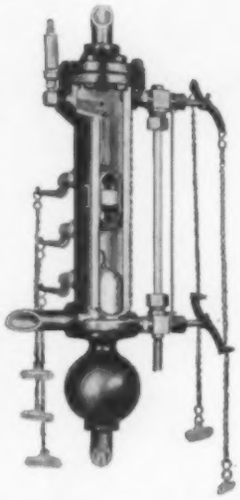
WELDING WITHOUT RODS...

... Short flanges left on deep-drawn Monel cups serve as filler metal in semi-automatic process

1 Strong, sound welds are essential for the floats in the Reliance gauge column shown at right. And the metal employed must be strong and corrosion resistant. For these floats are subjected to direct boiler pressures up to 900 lbs.... and the slightest leak means failure.



2 (*Below*) Blanks are deep-drawn to form cups in two operations, with a stress relief anneal in between. So a third quality essential in the metal used for Reliance floats is ease of fabrication. Another reason why Monel is standard for these floats!

3 (*Below*) Two half-floats ready for assembly on a steel reinforcing ring. Note that flanges shown in previous picture have been trimmed for welding, still leaving sufficient metal for a filler.

4 The assembled float is now placed in a specially designed lathe and oxy-acetylene welded by a semi-automatic method. The short flanges are melted down to form the weld. A reducing flame, with a slight excess of acetylene feather, is maintained as in gas welding of Monel and Nickel.

Photos courtesy of Reliance Gauge Column Co., Cleveland, Ohio.

5 Semi-automatic welding on a production scale calls for a metal with good welding qualities. When strength, toughness, and resistance to corrosion are also essential, Monel is a natural for the job.

Useful information on the welding of Monel and other high Nickel alloys is presented in "Welding of Monel and Nickel," "Welding of Inconel," "The Electric Welding of Monel and Nickel." Write for these booklets today. Ask also for the INCO Welding Shop Card, which gives condensed information in the form of a wall chart. Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

"Monel" is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately two-thirds nickel and one-third copper.

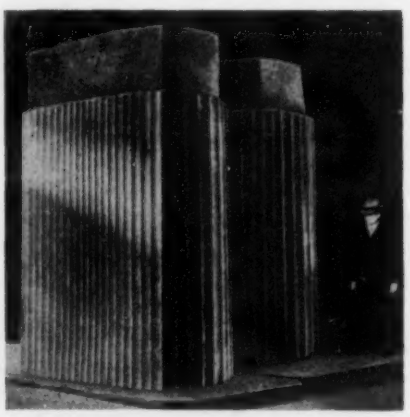
MONEL

PRODUCING STEEL PLATE FLYWHEELS 9 1/8 INCH THICK, WEIGHING 56,315 POUNDS EACH

Require 110,000 Lb. Ingots

In recent years, machine designers in increasing numbers have specified the use of rolled steel plates for flywheels.

Steel plate flywheels can be operated safely at much higher peripheral speeds. One steel flywheel now in service is reported to be used at peripheral speeds up to 14,000 feet per minute.



Two Ingots—Weighing 110,000 Lb. Each, Including Their 17,000 Lb. Hot Top, Made for Use in the Manufacture of Steel Plate Flywheels

In addition, the use of steel plate permits the designer to effect appreciable savings in flywheel weight, while eliminating pattern expense. One large machinery manufacturer prefers steel plate flywheels because they are easily designed, simplify flywheel manufacture, and give a neat appearance to the equipment on which they are used.

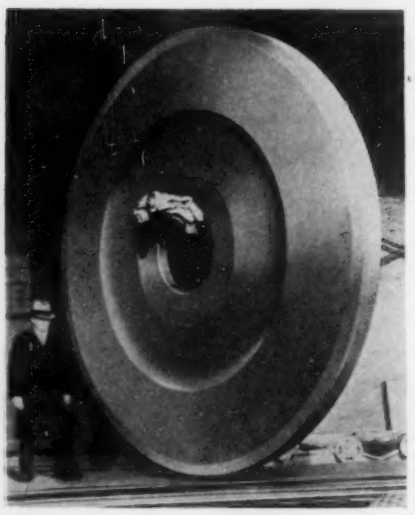
For Mesta Machine Company, mill and machinery manufacturers, Pittsburgh, Pa., Lukens Steel Company and its division, By-Products Steel Corporation, Coatesville, Pa., produced two steel plate flywheels, the largest and heaviest in gage and weight ever made in steel plate.

Each of these flame-cut steel plates,

From This Rectangular Rolled Plate 200 Inches Long, 170 Inches Wide and 9 1/8 inches Thick, Weighing 87,090 Lb., By-Products Steel Corporation, Coatesville, Pa., Flame-Cut a Circular Plate 165 1/4 Inches in Outside Diameter, Weighing 56,315 Lb.

before machining, weighed 56,315 lb., and measured 165 1/4 inches in diameter and 9 1/8 inches in thickness. They were used by Mesta Machine Company in the fabrication of flywheels for drives of a new hot wide strip mill in the Pittsburgh territory.

Production of these flame-cut steel plates required pouring of the two largest and heaviest ingots ever cast at Lukens, one ingot being made for each flywheel. The ingots were 135 inches high (including the 27 inches high hot tops), 90 inches wide and 40 inches thick. Each ingot weighed 110,000 lb., including the 17,000 lb. hot top.



One of Two Flame-Cut Plates

Each ingot was rolled on the Lukens 206-inch mill (which can produce plates up to 26 inches in thickness) into a plate 200-inch long, 170-inch wide and 9 1/8-inch thick, weighing 87,090 lb.

From each of these rolled plates, By-Products Steel Corporation flame-cut a circular plate, measuring 165 1/4 inches in outside diameter, 9 1/8 inches thick, with a shaft hole 29 inches in diameter in the center. Each flame-cut plate weighed 56,315 lb., and they are the heaviest steel plates ever produced.

After flame-cutting, the circular plates were transferred to the Lukens machine shops, and there smooth-machined on the inside diameter to a tolerance of plus 0, minus 0.005 inch, to shaft hole size of 31.015 inches. Other surfaces were rough machined to finished flywheel size of 164 1/4 inches in outside diameter and 8 3/16 inches in thickness, weighing 49,850 lb.

WELDING CONFERENCE

The University of Kansas held its fifth annual successful Welding Conference on April 13th and 14th. The program was published in the May issue of THE WELDING JOURNAL under the Kansas City Section activities. This program was prepared in cooperation with manufacturers, distributors and engineers in Kansas City. There was a total attendance of around 500 of which approximately 80% were students.

A new feature of the conference was the dinner held at the Memorial Union Building on the night of the thirteenth under the auspices of the Kansas City section of the AMERICAN WELDING SOCIETY in honor of the visit of the Vice-President Mr. K. L. Hansen. The attendance at the dinner was 42.

A notable feature of the conference was the indication of the growing interest toward welding among engineering students and the increasing tendency of manufacturers to send in their foremen and welding supervisors.

ANNUAL MEETING
Chicago,
Oct. 22nd-27th

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WELDING AND CUTTING EQUIPMENT
- Welding Torches
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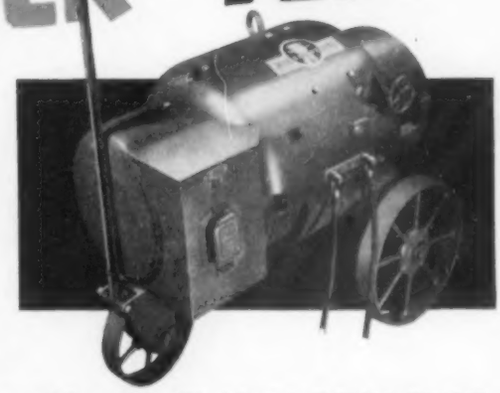
ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

MAKE THE "SHOE-LEATHER" TEST

Welding pays off in feet of work *completed* — not in footwork! That's why the FlexArc Welder with just ONE PRE-SET CONTROL gets more welding done at lower cost. No chasing back and forth to check current — no need for readjustments after the machine warms up. Just set it for the current required and *get* it — for one hour or ten!

Whether your operations involve welding at a distance from the welder or not, FlexArc's simplified control offers savings you should know about before you put money into any welder. Ask for a demonstration and make *your own* test! Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-20815



NOW . . . YOU CAN RENT A FLEXARC WELDER

Mail the coupon — get the facts about FlexArc's exclusive features and the FlexArc rental plan. Rental applies against later purchase in full.

Westinghouse Flexarc Welders

LET'S HAVE A SHOWDOWN!

- ☐ Please arrange a FlexArc demonstration
- ☐ I'm interested in full details on FlexArc and the FlexArc rental plan

Name _____

Company _____

Address _____

City _____

OBITUARY

Dr. C. F. Hirshfeld

Dr. C. F. Hirshfeld, internationally known educator and engineer, Chief of Research of The Detroit Edison Company, died at Grace Hospital at 3:15 P.M., April 19, 1939, after an illness of several months. He is survived by his wife, the former Elizabeth Winslow, two sons, Dr. John W. Hirshfeld of New Haven, Connecticut, a second son, James F. and a granddaughter, Elizabeth Slade Hirshfeld. Dr. Hirshfeld was distinguished in numerous fields, his work including consulting practice in several branches of engineering, many noted research activities, war service in 1918–19 with the rank of Lt. Colonel in the U. S. Ordnance Department, the writing of many books and papers on Engineering subjects (he was author of the chapter on Power in Dr. Charles A. Beard's composite work—"Toward Civilization" published in 1930), and in recent years the development of the P. C. C. street car, a revolutionary advance in the field of urban transportation involving welded construction.

Born in San Francisco, California, on January 30, 1881, Dr. Hirshfeld graduated from the University of California in 1902, with the degree of Bachelor of Science in Electrical Engineering. In 1903 he became an instructor at Cornell University and in 1905 received the degree of Master of Mechanical Engineering from the institution. He remained a member of the

Dr. C. F. Hirshfeld

faculty until 1913, advancing to the positions of Assistant Professor and Professor of Mechanical Engineering. During this period he was author and co-author of several text-books on steam power and internal combustion engines which are still classics in their field. In addition to his academic duties, he carried on an extensive consulting practice.

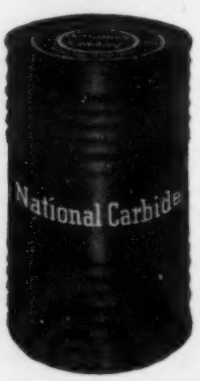
In 1913 he became associated with The Detroit Edison Company as Chief of Research, a position held until his death. He organized the Research Department of this company, which is believed to have been the first such department established and maintained by an electricity supply company. Many other public utilities have since established similar departments using this as a model. Dr. Hirshfeld has directed researches in a wide variety of fields including problems dealing with the design, construction, operation and maintenance of steam-electric power plants and the operation and interconnection of the electrical system; industrial electric heating and other load building efforts; disposal of industrial waste; problems in electric cable deterioration, electric welding, development of electric furnaces and new methods of generating electrical energy. He initiated many projects falling in highly specialized fields of physics, chemistry and electricity and was internationally recognized as an authority in many branches of engineering.

Various honors have been conferred upon Dr. Hirshfeld in recognition of his accomplishments. In 1932 Rensselaer Polytechnic Institute conferred the honorary degree of Doctor of Engineering upon him; in 1934 he was awarded the American Institute of Electrical Engineering national prize for the best paper on public relations and education, for his paper "Engineers of the Next Generation;" and he was the recipient of the Worcester Reed Warner Medal at the Annual meeting of American Society of Mechanical Engineers in December 1937. In June 1938, he was awarded the honorary degree of Doctor of Engineering by the University of Detroit.

Dr. Hirshfeld's outstanding achievement was his ability to apply research methods

National

Carbide



DEPENDABLE

EFFICIENT

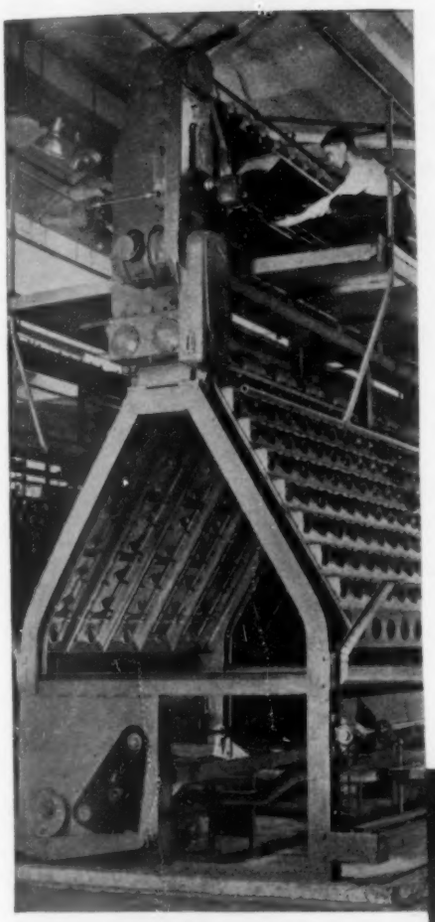
ECONOMICAL

FOR WELDING and CUTTING

Use National Carbide in the Red Drum

Lincoln Building — NATIONAL CARBIDE CORPORATION — New York, N. Y.

All-Welded, Rolled Steel Construction Makes *Miracle Machine* Possible!



Set-up of the all-welded structural frames for the continuous spinning process machine units—operator's walkway at the process panel level not yet installed, but its supporting brackets are in place. Each unit has an individual motor drive and is composed of 5 intermediate A-frames, one end-drive A-frame with machinery box, 10 process panels, spin frames, spin transmission beams, machinery brackets and various other miscellaneous structural parts.

Here's the heart of the newest, most revolutionary production cycle the viscose rayon industry has seen in years. A close-up view of the stepped process panel showing pressed steel cups welded to the inclined skin plate. These cups, counterbored to a tolerance of .001 inch diametrically and held to a close vertical alignment and parallelism, act as retainers for flanged bearings supporting the process reels. Accuracy, rigidity and perfect alignment of the hundreds of moving parts on the panel were obtained through an unusual job of jig welding.

Sets new standards of precision . . . at approximately half the cost of previous methods of construction

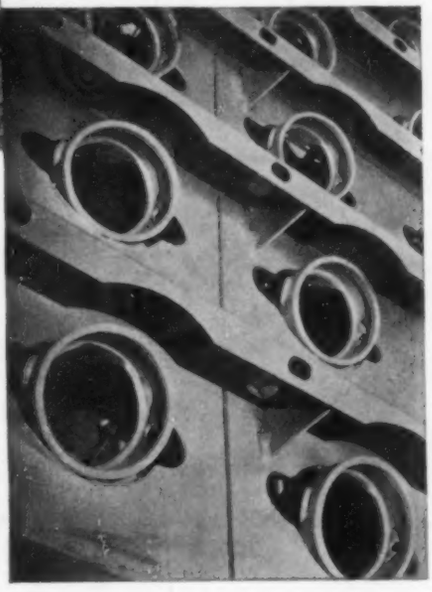
THEY said it couldn't be done. But here it is! The world's first commercial installation for the continuous spinning, processing, drying and twisting of viscose rayon yarn in one machine. 96 of these machines were installed in the new Painesville, Ohio, Plant of the Industrial Rayon Corporation. They will eliminate handling and interruptions, and produce a higher quality, uniform yarn more economically than ever before.

And all-welded construction with U·S·S Rolled Steel made it economically possible! Rolled steel construction effected a large reduction in weight . . . and a clean-cut structure devoid of complicating details and multiplicity of small parts.

The structural steel frames for these machines were fabricated by American Bridge Company. Each of the 96 units is 10 ft. 1 in. wide, 45 ft. 1 in. long and about 19 ft. high. Not merely the quantity involved, but the extreme accuracy required to assure perfect alignment needed constituted a problem which was economically solved by a resourceful, efficient combination of welding and U·S·S rolled shapes.

This revolutionary use of rolled steel construction opens a new realm of possibility for the fabrication and design of industrial equipment. From the experience gained on this contract, it is believed that many types of machine frames and supports, hitherto thought impractical to fabricate by welding, may now be undertaken with confidence.

We offer special steels in widest range. And our experience in putting these steels to work is yours for the asking. Investigate the economies, the added life, the strength, and speed of fabrication that rolled steels can give to equipment you fabricate.



Here are a few of the variety of special steels with special properties to overcome destructive forces in your rolled steel construction:

U·S·S HIGH TENSILE STEELS
to carry high unit stresses and to reduce weight to a minimum at low cost.

U·S·S ABRASION RESISTING STEELS
to reduce wear and cut replacements.

U·S·S CARILLOY ALLOY STEELS
to carry tremendous bearing pressures.

U·S·S HEAT RESISTING STEELS
to endure high temperatures that spell disaster to other metals.

U·S·S STAINLESS STEELS
to resist corrosive environments, to assure long life. Special analyses can be welded with no loss in corrosion resistance.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

to any type of problem. He was president of the Utilities Coordinated Research, Inc., formed by a group of electric utility companies—whose purpose is to coordinate research of various operating companies, and to promote group research studies of a very wide and general interest to the sponsors.

Dr. Hirshfeld was a great humanitarian and lover of men with a particular and intense interest in the welfare of young men with whom he always closely associated himself and who often sought his counsel.

Col. Oscar E. Engler

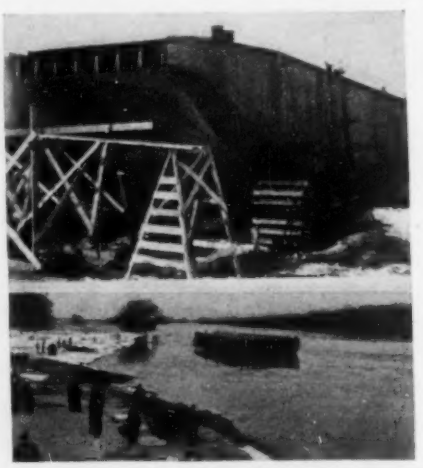
Col. Oscar E. Engler, President and General Manager of The Balbach Co., Omaha, Nebr., died on February 11th. Col. Engler had been identified with The Balbach Co. since 1919 and was very active in numerous organizations, both within the welding industry and outside of it. He was a past-president of the Reserve Officers' Association of the United States, and past-president of the Associated Industries of Nebraska and a past-president of the Omaha Manufacturers' Association. Col. Engler was a director of the National Oxygen and Acetylene Association and of the National Association of Manufacturers.

Born in Omaha, Nebr., September 20, 1875, his entire business career was devoted to advancing the interests of his business and community. He was commissioned a Lieutenant Colonel, Infantry Reserve, of the U. S. Army, and a member of the general staff of the organization "Military Order of the World War." Col. Engler is survived by his widow, Mrs. Oscar E. Engler of Omaha, and two sons, Paul E. Engler of Omaha and Capt. Howard E. Engler of the U. S. Army Air Corps, Fort Leavenworth, Kans.

TWELVE NEW HAY STEEL BARGES

Early in February the John I. Hay Co., a contract carrier operating in the Chicago district and on the Illinois and upper Mississippi Rivers, watched the first of its twelve new barges slip into the icy waters of the Illinois River.

These new barges are all identical, being of all steel and welded construction, not any wood being used in them. All are also of the same dimensions—180 ft. long, 42 ft. wide and 11 ft. deep, each having a capacity of 1500 tons. They are hopper type construction and designed for the handling of sand, gravel, crushed stone, coal and similar bulk cargoes. Each has a 19-ft. rake at the bow to reduce the power required for pushing the barges through the water.



Scenes at Seneca, on the Illinois River, Showing the Newly Launched Barge of the John I. Hay Co., Giving a Good View of the Rake at the Bow as Compared with the Cut of the Stern

The addition of these twelve barges will bring the number of the units in the fleet of the John I. Hay Co. up to thirty-two. The present plan is to put the new barges into service transporting coal from Liverpool, some 40 miles south of Peoria, to Chicago. Some of the older units of the fleet consist of tank type barges, used for transporting gasoline, fuel oil and other liquid cargoes.

These steel barges were fabricated at the central plant of the Chicago Bridge and Iron Co. at Washington Heights, on Chicago's far southside, and were shipped by rail for assembly and welding to the company's barge yard at Seneca on the Illinois River.

NICKEL ALLOYS

This edition of Bulletin T-13, "Nickel and Nickel-Base Alloys. . . Their Use in the Design of Corrosion-Resistant Machinery and Equipment," carries many changes from the preceding one. The text has been enlarged and, for some sections, rewritten extensively; and the tables and curves revised to include the latest available information.

Additions have been made to Tables I and X to include data on the new alloys, Hastelloy B and Illium R. Tables XI and XVII are brought to date to record the corrosion rates of Nickel and Monel after five-year atmospheric exposure tests. The curves of Figs. 23 and 24 have been redrawn and extended.

» » » NEW SECTIONS « « «

SOUTHERN LOUISIANA SECTION

An organization meeting was held at the Delgado Trade School, New Orleans, on the evening of May 12th to organize the Southern Louisiana Section.

In response to a telegram, President Boardman took a plane from Chicago and attended the meeting. Mr. O. B. McLaughlan, of the Freeport Sulphur Company, presided at the meeting and was elected Chairman. The following additional officers were elected:

Secretary—Clyde Pine, The Isaac Delgado Trade School.

Treasurer—A. E. Abaunza, Dixie Mach. Welding & Metal Works.

Vice-Chairman—E. G. Smith, University of Louisiana.

An informal buffet dinner was served which was enjoyed by all those present. It is believed that this Section will start with at least 29 members in Grade C or higher.

PUGET SOUND SECTION FORMED

On Monday, April 17th, an organization meeting was held at the Engineers' Club in Seattle, at which were present 26 members and prospective members. At this meeting it was decided to organize a section of the American Welding Society to be known as the Puget Sound Section and to embrace the Puget Sound area including possibly those interested in Vancouver, B. C. The required number of members have already been secured.

It is planned to hold meetings monthly with the possible exception of summer months, at the Engineers' Club, 9th floor Arctic Building, Seattle.

The following officers and committees were appointed:

Chairman—H. Haynes, Commercial Boiler Works.

Vice-Chairman—G. Morgan McBride, Air Reduction Sales Co.

Secretary-Treasurer—L. A. Burque, Westinghouse Elec. & Mfg. Co.

Program Committee—L. A. Burque, Chairman, Alex Thompson, R. S. Winship, G. S. Morgan, E. Hinton.

Building Code—Frank Conrad, Chairman, Alex Thompson, S. E. Brett.

By-Laws—H. A. Cheever, Chairman, William Flint, J. D. Hallum.

Membership—E. F. Flohr, Chairman, J. A. Luetke, J. B. McCormick, G. S. Morgan, R. S. Russell.

QUAD-CITIES SECTION ORGANIZED

On April 12th the final organization meeting was held at which enough members were secured to bring the total number of membership well over the minimum requirements of the By-Laws.

At the organization meeting Mr. A. M. Unger, Welding Engineer, Pullman Car & Manufacturing Company, presented a paper on "Welding Light Weight Cars."

The new Section is to include Moline, East Moline, Rock Island and Davenport. The following officers and directors were elected:

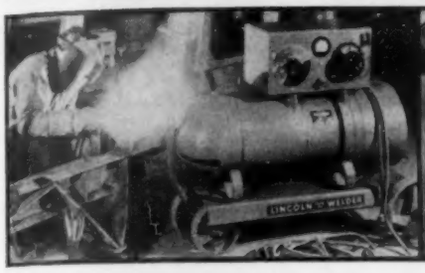
Chairman—A. R. Gustafson, Moline Welding Service

Vice-Chairman—Milton Deets, International Harvester Co.

Secretary-Treasurer—A. T. Cox, Jr., The Lincoln Electric Co.

Directors—A. R. Gustafson, A. T. Cox, Jr., Milton Deets, H. H. Harris.

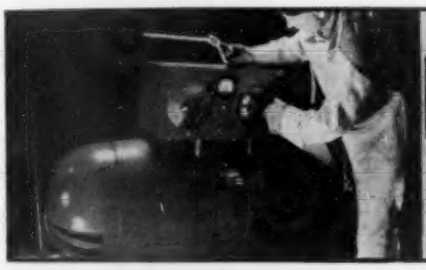
WHAT DO YOU KNOW *about arc welding machines?*

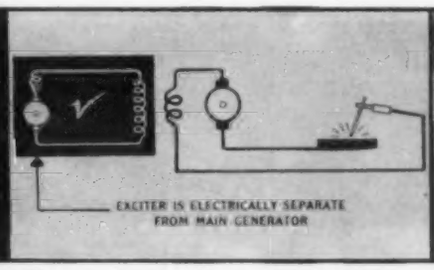


1. How can large electrodes be used for faster welding without danger of burnout? Answer: By using a *"Shield-Arc."* Its motor provides positive and complete protection from burnout, making possible sustained operation at high average loads.

2. What is the full meaning of *"Shield-Arc's"* Self-Protection? It prevents burnout *from any cause*...sustained overload, single-phase running, high or low line-voltage, phase unbalance or impaired ventilation...avoiding delays and expense.

3. How can the TYPE of welding arc be varied to suit various joints and working conditions for maximum speed and quality on *every* job? Answer: With a volt-ampere-slope control. Only *"Shield-Arc"* has this "Job Selector."

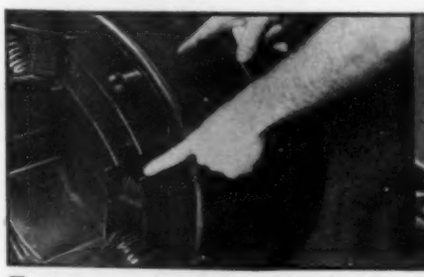




4. What welder provides *continuous* selection of both the TYPE of arc and the AMPERAGE with all settings marked right on the control dials? Answer: *"Shield-Arc."* This simplifies "setting" and minimizes welding cost.

5. How does Lincoln Separate Excitation improve welding? Answer: It acts like an electrical flywheel, providing constant power for a steady arc under all welding conditions, assuring easier welding and quality results.

6. How can you assure long life for brushes and commutator? Answer: Buy a *"Shield-Arc"* and eliminate the need for brush-shifting. The brushes are fixed at the factory for *permanent* sparkless operation. They seldom require attention.



7. What advantage has *"Shield-Arc's"* Laminated Magnetic Circuit over solid iron? Answer: It quickens the generator's response to changing conditions at the arc. Assures faster welding and less spatter under all conditions.

8. What two types of polarity switches are used on welders? Answer: One type is in the welding circuit. The other (*"Shield-Arc's"*) is in the excitation circuit —it carries no heavy current to burn contacts and can be used as a disconnect.

9. Why can thin-gauge material be welded so effectively and economically with a *"Shield-Arc"* Welder? Answer: Because its Dual Continuous Control makes available extremely low current values without need for wasteful resistances.

For further details, consult the nearest Lincoln office or mail the coupon

Largest Manufacturers of Arc Welding Equipment in the World

THE LINCOLN ELECTRIC COMPANY

CLEVELAND, OHIO

THE LINCOLN ELECTRIC CO., Dept. DD-613, Cleveland, O.
Send further explanation of [1] [2] [3] [4] [5] [6] [7] [8] [9]. Send free bulletin on *"Shield-Arc"* Welder.

Name _____ Position _____

Company _____

Address _____

City _____ State _____

List of New Members

April 1, 1939 to April 30, 1939

BIRMINGHAM

Brooks, W. E. (B), Tennessee Coal, Iron & R. R. Co., Fairfield, Ala.
Godwin, J. M. (D), 1620 No. 25th St., Birmingham, Ala.
Handley, A. B. (D), 11–17—23rd St. No., Birmingham, Ala.
Lewis, N. H. (D), 829½, Graymant Ave., Birmingham, Ala.
McCain, W. W. (D), 1802—14th Ave., Bessemer, Ala.
Montebana, Joe (D), 712 No. 20th St., Birmingham, Ala.
Ray, M. H. (D), 974-A 50th St. No., Birmingham, Ala.
McKinney, L. T. (D), Route 1, Irondale, Ala.
Sisk, J. W. (D), Route 1, Box 51, Irondale, Ala.

BOSTON

D'Arcy, Raymond A. (C), 12 Haror View Rd., Nahant, Mass.
Mason, Frederick D., Jr. (D), 319 Essex St., Salem, Mass.

CANADA

Morris, Ernest J. (D), Reserve, Sask, Canada.

CANTON

Keplinger, John C. (A), Hercules Motors Corp., Canton, Ohio.

CHICAGO

Adams, David (B), 3115 Grand Blvd., Brookfield, Ill.
Baumler, Harold A. (D), 8145 S. Bishop St., Chicago, Ill.
Long, V. K. (D), 4557 Diversey Ave., Chicago, Ill.

CINCINNATI

Becker, Clarence W. (C), The National Cylinder Gas Co., 4620 Este Ave., Cincinnati, Ohio.

CLEVELAND

Jacob, F. B. (C), 2010 East 102nd St., Cleveland, Ohio.

CONNECTICUT

Bittner, Henry (C), Nash Engineering Co., South Norwalk, Conn.

DETROIT

Austin, Byron B. (D), 156 W. Colgate Ave., Pontiac, Mich.
Elliott, Thomas C. (D), 3339 Blaine Ave., Detroit, Mich.
Horne, Marvin R. (C), 22187 W. Michigan Ave., Dearborn, Mich.
Moran, Thomas P. (C), General Motors Corp., 6307 W. Fort St., Detroit, Mich.

HAWAII

Ryan, C. M. (C), Hawaiian Gas Products Co., Box 2454, Honolulu, T. H.

LOS ANGELES

Chandler, Ezra A. (C), Western Pipe & Steel Co., 5717 Santa Fe Ave., Los Angeles, Calif.
McCaffrey, M. P. (C), 2121 E. 25th St., Los Angeles, Calif.
O'Callaghan, J. J. (C), The Linde Air Products Co., 2305 E. 52nd St., Los Angeles, Calif.
Schlittler, H. F. (B), Abegg & Reinhold Co., 2533 E. 26th St., Los Angeles, Calif.
Thompson, Moreton R. (B), 810 So. Flower St., Los Angeles, Calif.

MARYLAND

Lahn, Sydney (B), Maryland Welding Inst., 1022 Cathedral St., Baltimore, Md.

MILWAUKEE

Friese, A. H. (C), Welding Engrg. Co. 264 E. Ogden Ave., Milwaukee, Wis.
Young, Raymond A. (B), Young Sales, Inc., 1032 So. 41st St., Milwaukee, Wis.
Young, Willard A. (C), Young Sales, Inc., 1032 So. 41st St., Milwaukee, Wis.

NEW YORK

Applegate, M. W., Jr. (C), 1816 E. 21st St., Brooklyn, N. Y.
Friedrich, Wolfgang (B), 222 Riverside Drive, New York, N. Y.
Greenewald, E. L. (B), Union Carbide & Carbon Res. Labs., 30 E. 42nd St., New York, N. Y.
Johnson, Lloyd C. (F), 20 Pershing Ave., Milltown, N. J.
Martensen, Leonard R. (C), 458—14th St., Brooklyn, N. Y.
Mitchell, William (C), 19—4th Ave., Brooklyn, N. Y.
Morton, A. F. (D), 3803 Snyder Ave., Brooklyn, N. Y.
Pitou, Eugene (B), The Patent Scaffolding Co., 3821—12th St., Long Island City, N. Y.
Pursell, Robt. T. (C), 11 Park Place, Bloomfield, N. J.
Randall, John F. (B), Combustion Engrg. Co., 200 Madison Ave., New York, N. Y.
Taylerson, John E. (C), 77 Woodward Ave., Rutherford, N. J.

NORTHERN NEW YORK

Reed, Clifford H. (C), 84 James St., Schenectady, N. Y.

WESTERN NEW YORK

Murta, Clarence (D), Alexander, N. Y.

NORTHWEST

Sworski, Stanley F. (D), 618 Huron St., S. E., Minneapolis, Minn.

OKLAHOMA CITY

Dawson, James K. (F), R.R. No. 2, Stillwater, Okla.

PHILADELPHIA

Saul, Harry H. (C), 125 W. 18th St., Wilmington, Del.
Viohl, Herbert K. W. (B), Benjamin F. Shaw Co., Wilmington, Del.

PITTSBURGH

Cline, Charles R. (D), 1327—8th Ave., New Brighton, Pa.
Godfrey, Vincent H. (B), Page Steel & Wire Div. of American Chain & Cable Co., Monessen, Pa.
Nevin, K. S. (B), Railway & Industrial Engrg. Co., P. O. Box 98, Greensburg, Pa.

SAN FRANCISCO

Delhi, L. W. (B), Western Pipe & Steel Co., 444 Market St., San Francisco, Calif.
Phillips, Seward (F), 457-B Van Dyke Ave., Oakland, Calif.

SAN JOAQUIN

Johnson, W. M. (D), Mitchell Farms, Rt. 1, Box 120, Arwin, Calif.
Smith, Roland (D), Baash Ross Tool Co., Bakersfield, Calif.
Straw, Gilbert (D), Box 414, Arwin, Calif.
Van Leuven, E. P. (D), 2716—21st St., Bakersfield, Calif.
Winn, Carl D. (D), Box 581, Maniopa, Calif.

ST. LOUIS

Brocklebank, P. T. (B), J. P. Devine Mfg. Co., Mt. Vernon, Ill.
Collison, Thomas A. (B), Mt. Vernon Car Mfg. Co., Mt. Vernon, Ill.
Streett, James D. (C), Granite City Steel Co., 1804 Boatmens Bank Bldg., St Louis, Mo.

WASHINGTON, D. C.

Blanton, John W. (D), 3021 E. Linwood Ave., Parkville, Md.
Hodge, Frank N. (C), 811 G St. N. E., Washington, D. C.

WICHITA

House, H. T. (D), 328 N. Minn., Wichita, Kansas.
Stepleton, P. W. (D), 3033 Wellington Place, Wichita, Kansas.

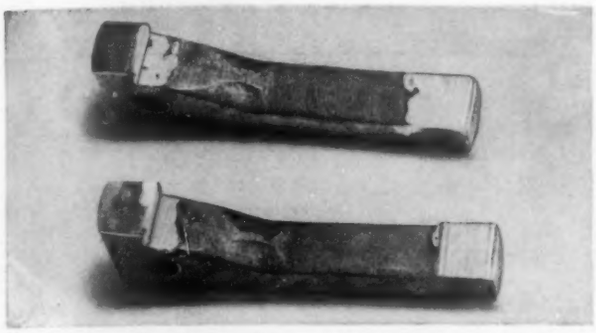
YOUNGSTOWN

Allen, Ben L. (D), 203 White Ave., Sharon, Pa.

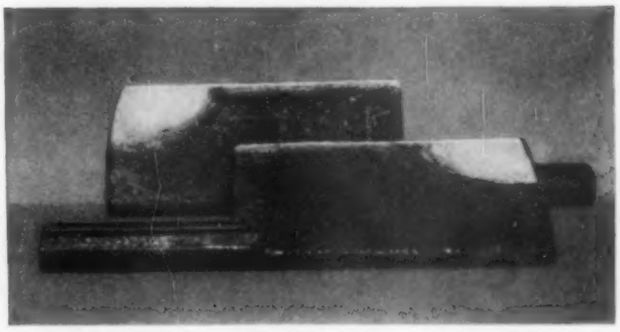
NOT IN SECTIONS

Beyreuther, Robert (B), 116 Boise Dr., Syracuse, N. Y.
Fladland, Henry G. (D), P. O. Box 308, Bremerton, Wash.
Lloyd, J. F. (B), 81 Forfar Rd., Tuebrook, Liverpool, 13, England.
Mummey, L. R. (D), Mt. Shasta, Calif.
Stibbs, Edward G. (B), Trinidad Leaseholds, Ltd., Pointe-A-Pierre, Trinidad, B.W. 1, British West Indies.

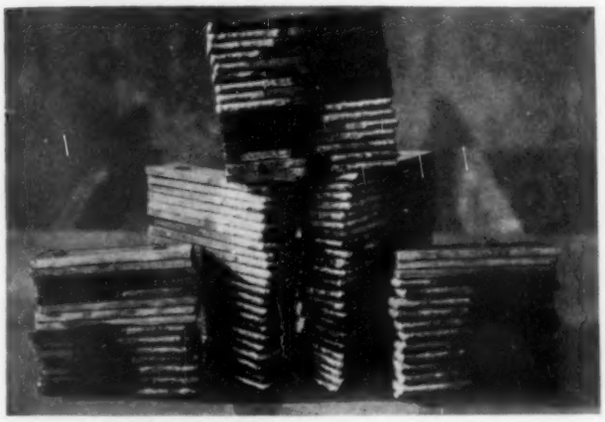
Reduce wear in your industry with HAYNES STELLITE ALLOY



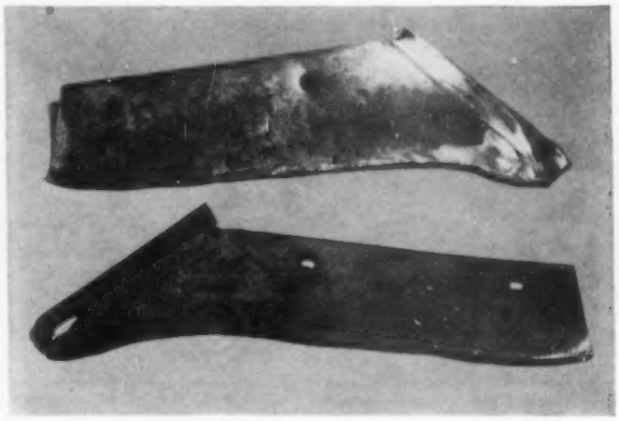
MACHINERY—These clutch fingers for automatic hobbing machines, hard-faced with Haynes Stellite alloy by the manufacturer, have ten times the life of plain steel fingers.



BRICK—These pug mill knives, used in the manufacture of brick, have been hard-faced with Haynes Stellite alloy to give them three times the service life of knives not hard-faced.



CHEMICAL—These charcoal mill hammers, hard-faced with Haynes Stellite alloy, lasted 36 weeks before requiring hard-facing again; unsurfaced hammers had to be discarded after 6 weeks of use.



AGRICULTURE—This unretouched photograph shows two plowshares, hard-faced with Haynes Stellite alloy, after they had plowed 600 acres of "Iowa gumbo," containing much abrasive material, over a period of 6 years.

Write for the 104-page book, "Hard-Facing With Haynes Stellite Products, W2-6," which shows how these products can reduce wear and save money for you. There is no obligation.

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

"Haynes Stellite" is a registered trade-mark of Haynes Stellite Company.

HAYNES STELLITE TRADE MARK

Red-hard, wear-resisting alloy of cobalt, chromium and tungsten

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

Chicago · Cleveland · Detroit · Houston · Los Angeles · New York · San Francisco · Tulsa

General Office and Works—Kokomo, Indiana
Foreign Sales Department—New York City

Haynes Stellite hard-facing rods and information on other Haynes Stellite Company products also are available through all apparatus shipping points of The Linde Air Products Company

Sustaining Companies

Grinnell Company, Inc., 260 West Exchange St., Providence, R. I. Executive Offices are in Providence, but Sales Offices and Branches are located in the principal cities of the United States and Canada. Maintains Prefabricating Plants in Atlanta, Ga., Cranston, R. I., and Warren, Ohio, where complete facilities are available for prefabrication of all classes and types of piping including Bending, Van Stoning, Welding and Heat Treating of carbon and alloy steels used in Power Plants, Process Plants and Oil Refineries.

Hercules Motors Corporation, General Offices, Canton, Ohio. Factories, Canton, Ohio and Muskegon, Mich. Oil Field Sales and Service Branches, Houston and Kilgore, Texas. Manufacturers of a complete line of modern gasoline and Diesel Engines for Heavy Duty Service—2, 4 and 6 Cylinder models, ranging from 4 to 200 hp. World's largest manufacturer specializing in the design and production of Internal Combustion Engines, exclusively. Hercules engines, both gasoline and Diesel, are widely used in the Welding Industry.

M. W. SMITH ELECTED TO VICE-PRESIDENCY OF WESTINGHOUSE ELECTRIC

Marvin W. Smith, Manager of Engineering of the Westinghouse Electric & Manufacturing Company, has been elected a Vice-President of the company by the Board of Directors on April 26, 1939. Mr. Smith, who will direct all the company's engineering activities, has been associated with Westinghouse since the day he left college in 1915.

Coming to Westinghouse because he "was interested in electricity," Mr. Smith began as a student engineer, did shop and office work, then moved steadily upward. He has been Manager of Engineering since May 7, 1936, during which time the company has produced several major new developments in engineering, including the Precipitron, new electric air-cleaner; new lines of improved switchgear for the safe, rapid and economical handling of high-voltage electricity; and has launched into new areas of fundamental scientific and engineering research, including studies of the nature of matter and experiments in "smashing the atom."

PROTECTION OF THE EYES FOR WELDING

A very interesting pamphlet has been published by The Lincoln Electric Company of Cleveland, Ohio, on the above subject. Copies available on request.

FIFTIETH ANNIVERSARY

The Heating, Piping and Air Conditioning Contractors National Association, will celebrate their 50th Annual Convention and the 50th Anniversary of the Organization, May 31st, June 1st and 2nd, at The Drake Hotel, Chicago, Illinois. It is expected that the Society will be represented by President Boardman.

EMPLOYMENT SERVICE BULLETIN

Replies should be addressed to Key Numbers and sent to the office of the AMERICAN WELDING SOCIETY

SERVICES AVAILABLE

A-313. Executive available. Experienced shielded-arc electrodes; modern methods of manufacture; Research; Coatings and Welding; Technical Sales; Patents. Fully qualified to take complete charge.

A-314. Welding Engineer and Doctor of Technical Service. Experienced in Electric Arc and Gas Welding, Soldering and Cutting; mechanical and metallurgical testing of welds and rods; layout of welded constructions, sales and maintenance of welding equipment; welding repairs. Desires position as Welding Specialist, Welding Supervisor, etc.

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

The April 5th meeting was held in the Alabama Power Company Auditorium with a total attendance of 80 members and guests. Mr. E. R. Seabloom, Research Engineer, Crane Company, the guest speaker, presented an interesting address on "The Application of Fusion Welding to Pressure Piping." In addition to the guest speaker, the following individuals visited the meeting: M. L. Eckman, Chief Engineer, American Coach & Body Co., Cleveland, Ohio, and Arvid Nihlin, American Heat Reclaim Corp., N. Y. C., home address Stockholm, Sweden.

BOSTON

At the annual meeting of the Boston Section held on April 17th, the following officers were elected:

Chairman—F. B. Mehaffey, Air Reduction Sales Co.

Vice-Chairman—P. L. F. Feyling, Whitehead Metal Products Co., Inc.

Secretary-Treasurer—P. N. Rugg, Boston Edison Company

Trustee—A. L. Combs, The Linde Air Products Company

Directors—(Term expires in 1940) C. H. E. Coster, Worchester Boys Trade School; L. Gordon, Hobart Brothers Co.; S. J. Slater, Air Reduction Sales Co. (Term expires in 1941) H. G. Austin, Lukenweld, Inc.; D. A. Lee, Gas-Weld Equipment Co.; E. H. Swim, B. F. Sturtevant Co.

The Council of the Engineering Societies of New England, Inc., at its April 12th meeting, elected two members of the Boston Section to serve for the coming year. L. F. Jackson, Past-Chairman of the Boston Section, was elected First Vice-President, and Professor Albert Haertlein was elected Secretary of the Engineering Societies of New England. They take office on June 5th.

CHATTANOOGA

The Chattanooga Section of AMERICAN WELDING SOCIETY held a Banquet at 6:30 P. M., May 2nd, celebrating their winning the National Prize on Membership Drive, during the first three months of this year. There were approximately thirty-five members and prospective members present. Following the Banquet, at 8:00 P. M. Mr. H. C. Boardman, Research Engineer of the Chicago Bridge & Iron Company, and National President of the AMERICAN WELDING SOCIETY, gave a very interesting and well illustrated lecture on "Field Welding of Storage Tanks."

CHICAGO

The regular monthly meeting of the Chicago Section held on April 21st took place in the Chicago Lighting Institute. Mr. A. N. Kugler of the Applied Engineering Dept., Air Reduction Sales Co., presented his talk on "Oxyacetylene Welding and Brazing," which is a discussion of oxyacetylene welding as applied to steel: pipe, sheet metal, miscellaneous industrial applications; cast iron; brass, bronze, copper and aluminum.

Special added attraction was the showing of a sound movie presented by the Chevrolet Motor Company, entitled "Jack and the Bean Stalk."

DETROIT

The April meeting of the Detroit Section was held on the 28th in the Detroit-Leland Hotel. The speaker, Mr. S. M. Humphrey, Chief Electrical Engineer, The Taylor-

ROEBLING

the custom-made wire for exacting welders

★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

ROEBLING WELDING CABLES:

Made in a complete line of rubber and braided types for arc welding purposes.

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Grinnell Company, Inc., 260 West Exchange St., Providence, R. I. Executive Offices are in Providence, but Sales Offices and Branches are located in the principal cities of the United States and Canada. Maintains Prefabricating Plants in Atlanta, Ga., Cranston, R. I., and Warren, Ohio, where complete facilities are available for prefabrication of all classes and types of piping including Bending, Van Stoning, Welding and Heat Treating of carbon and alloy steels used in Power Plants, Process Plants and Oil Refineries.

Hercules Motors Corporation, General Offices, Canton, Ohio. Factories, Canton, Ohio and Muskegon, Mich. Oil Field Sales and Service Branches, Houston and Kilgore, Texas. Manufacturers of a complete line of modern gasoline and Diesel Engines for Heavy Duty Service—2, 4 and 6 Cylinder models, ranging from 4 to 200 hp. World's largest manufacturer specializing in the design and production of Internal Combustion Engines, exclusively. Hercules engines, both gasoline and Diesel, are widely used in the Welding Industry.

M. W. SMITH ELECTED TO VICE-PRESIDENCY OF WESTINGHOUSE ELECTRIC

Marvin W. Smith, Manager of Engineering of the Westinghouse Electric & Manufacturing Company, has been elected a Vice-President of the company by the Board of Directors on April 26, 1939. Mr. Smith, who will direct all the company's engineering activities, has been associated with Westinghouse since the day he left college in 1915.

Coming to Westinghouse because he "was interested in electricity," Mr. Smith began as a student engineer, did shop and office work, then moved steadily upward. He has been Manager of Engineering since May 7, 1936, during which time the company has produced several major new developments in engineering, including the Precipitron, new electric air-cleaner; new lines of improved switchgear for the safe, rapid and economical handling of high-voltage electricity; and has launched into new areas of fundamental scientific and engineering research, including studies of the nature of matter and experiments in "smashing the atom."

PROTECTION OF THE EYES FOR WELDING

A very interesting pamphlet has been published by The Lincoln Electric Company of Cleveland, Ohio, on the above subject. Copies available on request.

FIFTIETH ANNIVERSARY

The Heating, Piping and Air Conditioning Contractors National Association, will celebrate their 50th Annual Convention and the 50th Anniversary of the Organization, May 31st, June 1st and 2nd, at The Drake Hotel, Chicago, Illinois. It is expected that the Society will be represented by President Boardman.

EMPLOYMENT SERVICE BULLETIN

Replies should be addressed to Key Numbers and sent to the office of the AMERICAN WELDING SOCIETY

SERVICES AVAILABLE

A-313. Executive available. Experienced shielded-arc electrodes; modern methods of manufacture; Research; Coatings and Welding; Technical Sales; Patents. Fully qualified to take complete charge.

A-314. Welding Engineer and Doctor of Technical Service. Experienced in Electric Arc and Gas Welding, Soldering and Cutting; mechanical and metallurgical testing of welds and rods; layout of welded constructions, sales and maintenance of welding equipment; welding repairs. Desires position as Welding Specialist, Welding Supervisor, etc.

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

The April 5th meeting was held in the Alabama Power Company Auditorium with a total attendance of 80 members and guests. Mr. E. R. Seabloom, Research Engineer, Crane Company, the guest speaker, presented an interesting address on "The Application of Fusion Welding to Pressure Piping." In addition to the guest speaker, the following individuals visited the meeting: M. L. Eckman, Chief Engineer, American Coach & Body Co., Cleveland, Ohio, and Arvid Nihlin, American Heat Reclaim Corp., N. Y. C., home address Stockholm, Sweden.

BOSTON

At the annual meeting of the Boston Section held on April 17th, the following officers were elected:

Chairman—F. B. Mehaffey, Air Reduction Sales Co.

Vice-Chairman—P. L. F. Feyling, Whitehead Metal Products Co., Inc.

Secretary-Treasurer—P. N. Rugg, Boston Edison Company

Trustee—A. L. Combs, The Linde Air Products Company

Directors—(Term expires in 1940) C. H. E. Coster, Worchester Boys Trade School; L. Gordon, Hobart Brothers Co.; S. J. Slater, Air Reduction Sales Co. (Term expires in 1941) H. G. Austin, Lukenweld, Inc.; D. A. Lee, Gas-Weld Equipment Co.; E. H. Swim, B. F. Sturtevant Co.

The Council of the Engineering Societies of New England, Inc., at its April 12th meeting, elected two members of the Boston Section to serve for the coming year. L. F. Jackson, Past-Chairman of the Boston Section, was elected First Vice-President, and Professor Albert Haertlein was elected Secretary of the Engineering Societies of New England. They take office on June 5th.

CHATTANOOGA

The Chattanooga Section of AMERICAN WELDING SOCIETY held a Banquet at 6:30 P. M., May 2nd, celebrating their winning the National Prize on Membership Drive, during the first three months of this year. There were approximately thirty-five members and prospective members present. Following the Banquet, at 8:00 P. M. Mr. H. C. Boardman, Research Engineer of the Chicago Bridge & Iron Company, and National President of the AMERICAN WELDING SOCIETY, gave a very interesting and well illustrated lecture on "Field Welding of Storage Tanks."

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Special added attraction was the showing of a sound movie presented by the Chevrolet Motor Company, entitled "Jack and the Bean Stalk."

DETROIT

The April meeting of the Detroit Section was held on the 28th in the Detroit-Leland Hotel. The speaker, Mr. S. M. Humphrey, Chief Electrical Engineer, The Taylor-

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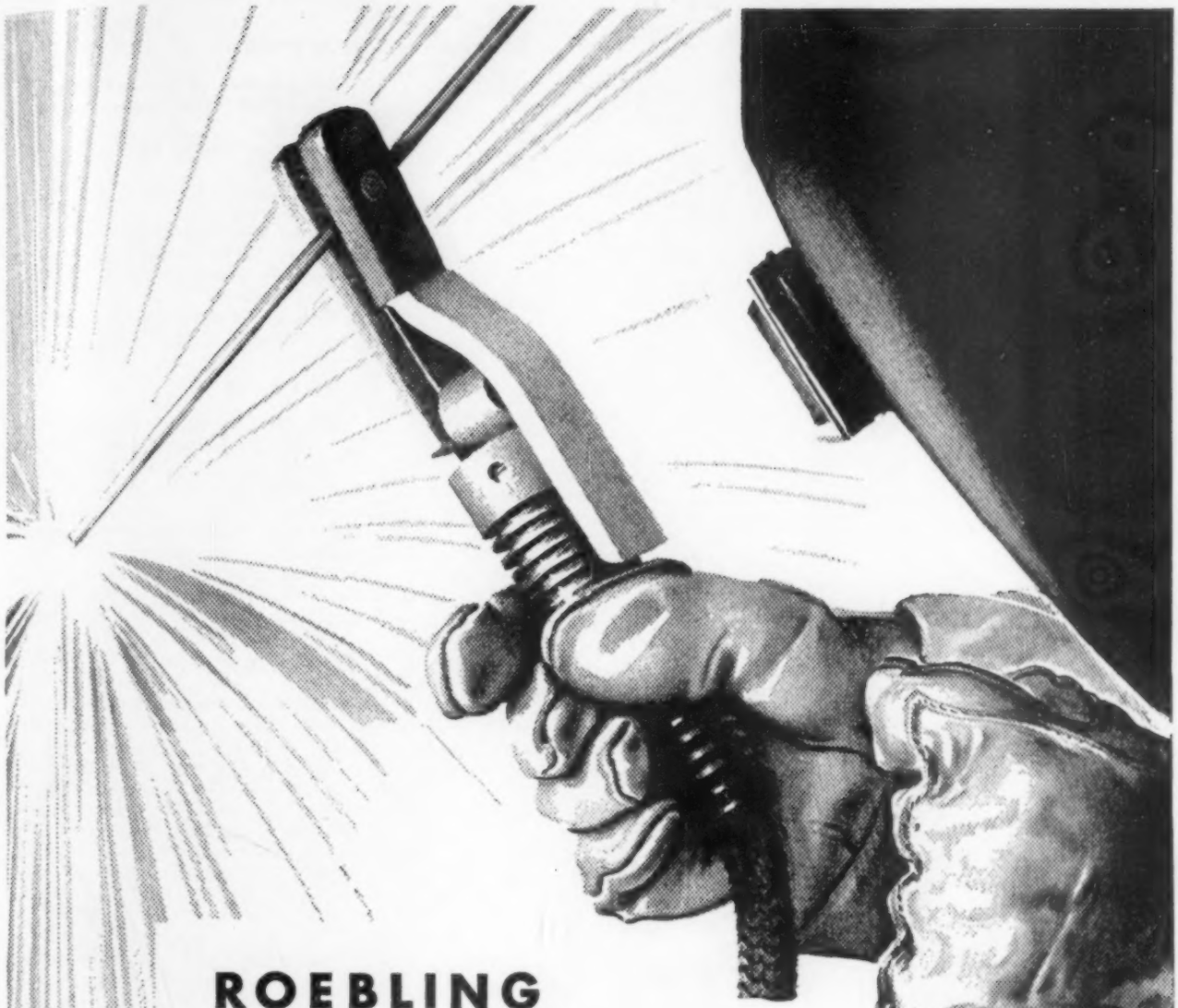

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Winfield Corporation, spoke on "The Electrical Fundamentals of Resistance Welding."

HAWAII

The January meeting of the Hawaiian Section held on the 27th took place in The Pacific Club. After dinner, the Chairman briefly outlined the events that took place at the demonstration given by the Hawaiian Section for the benefit of the Hawaiian Sugar Technologists.

The Chairman then read a letter from the Society headquarters pertaining to a membership drive now being conducted. A motion was made that the Hawaiian Section offer A.W.S. emblems to members who signed up new members. This offer was for the first three months of this year only.

A sound film showing the welding used in the construction of new transformer units was shown.

At the March 30th meeting, presentation of membership emblems was made to those who had brought in new members.

Mr. R. A. Plaus read a paper pertaining to the relative differences between bare and coated rods and reverse-polarity coated rods as compared with straight-polarity coated rods.

The remainder of the time was devoted to questions and answers and general discussion.

KANSAS CITY

Mr. C. H. Jennings, in Charge of Welding Research, Westinghouse Electric & Mfg. Co., presented an illustrated address on "Distortion Problems," at the May 15th meeting of the Kansas City Section.

LOS ANGELES

The regular meeting of the Los Angeles Section was held Thursday evening, April 20, 1939, on the 11th floor, Barker Brothers, Inc., 818 West Seventh Street, Los Angeles, California.

There were 104 members and guests present for the dinner, with approximately 125 attending the meeting.

The meeting was opened by Chairman P. D. McElfish, who appointed the Nominating Committee composed of Clayton M. Allen, Chairman, and Merrill H. Turner and Harold P. Etter, who were asked to report on the suggested nominations of officers and executive committee at the next regular meeting.

Mr. K. Van Ness King, Materials Engineer, Standard Oil Company of California, who is also Regional Vice-President, gave a very interesting talk on the "Preheating and Stress Relieving of Pressure Vessels." His talk was accompanied by a series of slides and charts.

The second speaker of the evening was Mr. C. C. Swift, Chief Welding Engineer, American Brass Company, Waterbury, Conn., who talked on the "Welding of Copper and Copper Alloys." Mr. Swift covered various copper alloys and their weldability, and the methods of welding very completely. After his talk, Mr. Swift answered a good many questions from the audience with regard to various applications.

MEMPHIS

A special meeting was called for Monday, May 1st, at which Mr. H. C. Boardman, President of the Society, gave a talk on "Field Welded Storage Tanks." The meeting was unusually well attended, with approximately eighty people present. The meeting was held in the auditorium of the newly completed Wm. R. Moore School of Technology. This is an endowed trade school, which has included in its curriculum a complete course on gas and electric welding. The school has very kindly consented to allow the Memphis Section to use their auditorium for future meetings.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on April 28th in the City Club of Milwaukee. Dinner preceded the meeting. Mickey Heath, Manager and first baseman of the Milwaukee Baseball Club, told some interesting baseball stories at the dinner.

"The Unionmelt Welding Process," an illustrated talk, was given by W. B. Browning, Service Engineer, The Linde Air Products Company.

NEW YORK

The following officers and directors of the New York Section were elected for the fiscal year:

Chairman—Charles Kandel, Craftsweld Equipment Co.

First Vice-Chairman—J. T. Phillips, Foster Wheeler Corp.

Second Vice-Chairman—J. W. Sheffer, American Car & Foundry Co.

Secretary-Treasurer—G. V. Slottman, Air Reduction Sales Co.

Executive Committee—J. L. Wilson, J. B. Tinnon, E. C. Rechtin, G. Schneider.

NORTHWEST

The Second Annual Meeting of the Northwest Section was held on May 17th in the Minnesota Union, University of Minnesota. Mr. E. F. Smith, District Sales Manager, Haynes Stellite Company, spoke on "Hard Surfacing." In addition to his discussion of the subject, Mr. Smith displayed some of the tools and special details that the company regularly manufactures.

OKLAHOMA CITY

The regular meeting of this Section was held on May 17th at the Huckins Hotel. Mr. Chas. H. Jennings, Engineer in Charge of Research, Westinghouse Electric & Mfg. Co., spoke on "Distortion Problems in Welding," and S. C. Hollister, Dean of the College of Engineering, Cornell University, spoke on "Fabrication of the Boulder Dam Penstocks."

PEORIA

The regular meeting of the Peoria Section of AMERICAN WELDING SOCIETY was held on Tuesday, May 2nd. The guest speaker was Mr. E. W. P. Smith, Consulting Engineer for Lincoln Electric Co., Cleveland, Ohio. Mr. Smith lectured on the subject, "Cost Reduction by a Study of Stress Distribution, Using Polarized Light, Plastic Models and Rubber Models."

About eight-five members and guests attended the meeting, and Mr. Smith's address was received with unanimously

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enthusiastic appreciation. His unique illustrations and splendid presentation made it a most profitable and pleasant meeting.

PHILADELPHIA

At the annual meeting of the Philadelphia Section held on April 17th, the following officers were elected:

Chairman—H. R. Salisbury, Air Reduction Sales Co.

Vice-Chairman—J. W. Allison, Westinghouse Elec. & Mfg. Co.

Treasurer—R. D. Thomas, Arcos Corp.

Secretary—H. E. Hopkins, Arcos Corp.

An annual inspection trip to the Philadelphia Navy Yard, League Island, was held on May 17th.

PITTSBURGH

The Second Annual Tri-State Conference was held by the Pittsburgh Section Friday, April 28th, in the Cardinal Room of the William Penn Hotel before capacity audiences.

Mr. R. P. Palmer, Welding Supervisor, Wheeling Steel Corporation, Steubenville, Ohio, gave a complete paper on the "Maintenance Welding in Steel Mills." He discussed many odd jobs done in his plant and under his supervision, and illustrated with slides the details of the work.

Through a sudden illness Mr. G. W. Linkhauer, Manufacturing Engineer, United Engineering & Foundry Co., was unable to present his paper on "Fabrication of Heavy Mill Machinery by Welding" and Mr. Jerry O'Brien, Assistant to the Chief Engineer for the same Company read the paper and discussed the subject.

The final paper of the afternoon session was presented by Mr. F. G. Outcalt, Welding Engineer, Unionmelt Division, The Linde Air Products Company, New York. Mr. Outcalt gave an exceedingly fine presentation of the Unionmelt Process, discussing in detail the many applications, results obtained and future possibilities. This was supplemented by three reels of films, showing the Unionmelt Process in actual operation.

At the evening session Mr. W. J. Chaffee, Territorial Director, Hobart Brothers Company, Troy, Ohio, gave his sound-slide presentation of the work the Hobart Company is doing on "Welded Steel Houses." His pictures show the houses in actual construction in the shop—from the sub-assembly, through the production line—until the entire house, complete with many fittings, is moved out the large doors in the far end of the especially designed factory building set up for this purpose. He also showed the complete buildings being hauled from the factory on enormous trailers, to the final settings in the several new developments now under construction by the Hobart Company.

Following the showing of the "Welded Steel Houses" Mr. Chaffee presented a second film showing the production line method of manufacturing the Hobart welding machines which was also very interesting.

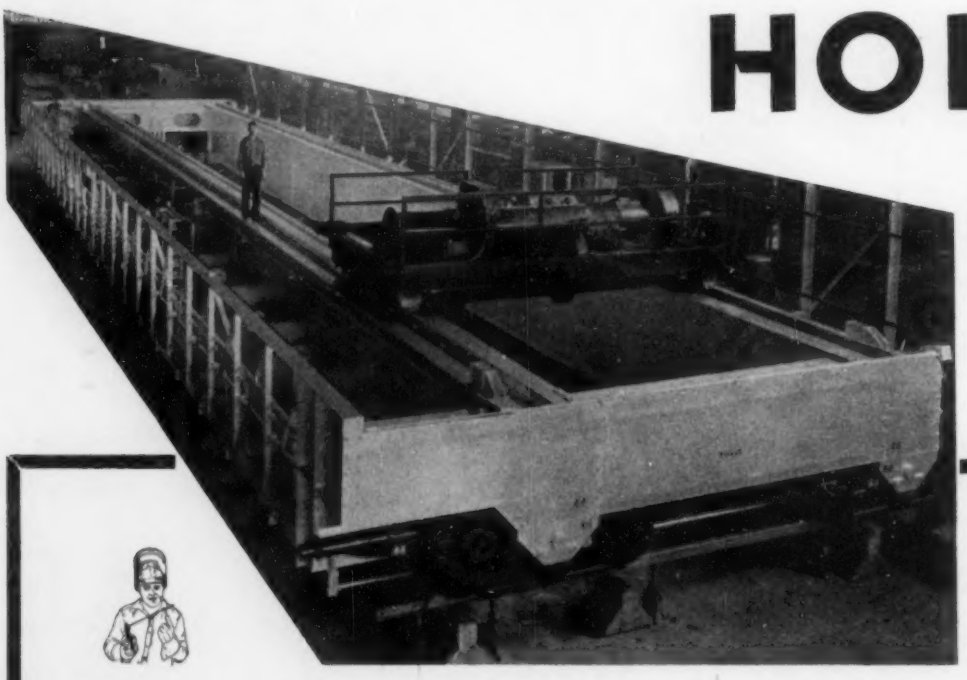
The Pittsburgh Section was fortunate in having present at the evening session Mr. F. T. Llewellyn, of the Carnegie-Illinois Steel Corporation, a former Past-President of the AMERICAN WELDING SOCIETY, who has had intimate connection with the development of steel houses both of the steel-frame and all-steel varieties. He gave a most interesting talk on the subject as he sees it and on what may be expected in the future. Mr. Llewellyn also announced his retirement, on age, from the Carnegie-Illinois Steel Company on the following day.

ROCHESTER

The Rochester Section held its May meeting on the 4th in the Todd Union, University of Rochester. Prof. Wendell F. Hess, Rensselaer Polytechnic Institute, addressed the meeting on "The Metallurgical Aspects of Welding."

ST. LOUIS

The regular monthly meeting of the St. Louis Section was held on May 12th in the Engineers Club Auditorium. Mr. C. H. Jennings, Research Engineer, Westinghouse Elec. & Mfg. Co., presented a talk on "Distortion Problems," which was well received.



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The Resistance Welder Manufacturers Association, through accumulated experience, has established specifications covering standard resistance welding machines. These specifications are essentially a code of ethics which the member companies maintain, thereby protecting the users of this equipment by providing definite standards to which it is built.

The specifications classify the various sizes and types of equipment, thus aiding the purchaser in the proper selection to suit his needs. They do not, however, in any way, limit the development of refinements or improvements which any member company is able to incorporate in its designs.

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Resistance Welder Manufacturers Association

505 Arch Street — Philadelphia, Pa.

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Acme Electric Welder Company, Los Angeles
American Electric Fusion Corporation, Chicago
Eisler Engineering Company, Newark, N. J.
Expert Die & Tool Company, Detroit
Federal Machine and Welder Company, Warren
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City
Progressive Welder Company, Detroit
Swift Electric Welder Company, Detroit
Taylor-Hall Welding Corporation, Worcester
Taylor-Winfield Corporation, Warren
Thomson-Gibb Electric Welding Co., Lynn
Welding Machines Mfg. Company, Detroit

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis
S-M-S Corporation, Detroit
Electroloy, Inc., New York
Welding Sales and Engineering Co., Detroit

SAN JOAQUIN VALLEY

The April 28th meeting held in Taft, California, was addressed by several students picked from the Vocational Welding classes of the Taft Junior College and the Bakersfield Junior College. They were:

George Schaffner, Taft Junior College, who spoke on "Multi-Layer Oxyacetylene Pipe Welding."

Clayton Vines, Bakersfield Junior College—"Technique of Welding Cast Iron."

Arden Hambly, Taft Junior College—"Principles of Bronze Welding."

Albert Sellers, Bakersfield Junior College—"Principles of Layout and Design."

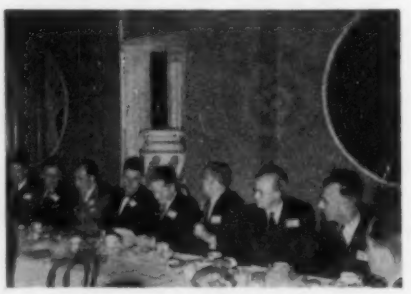
WASHINGTON, D. C.

The Washington Section held its Annual Dinner Meeting at the Lafayette Hotel on April 25th. There were about 130 present. The principal speaker was Mr. F. T. Llewellyn, Research Engineer of the U. S. Steel Corporation. Mr. Llewellyn's subject was "Seventy Years in Retrospect." Mr. Llewellyn in his humorous whimsical style gave a brief birds-eye view of his life and work, starting as a young boy and later on as a young immigrant at the age of 21. The audience was intensely interested in this life story of progress and accomplishments. In honor of the occasion, President Boardman and four past-presidents, C. A. Adams, C. A. McCune, D. S. Jacobus and P. G. Lang, were present. Also present was W. W. Petry, Divisional Vice-President. Other, out of town, visitors included a number of representatives of the Baltimore Section, Mr. Maurath of Cleveland, J. W. Meadowcroft of Philadelphia and W. Spraragen of New York.

A humorous touch was added when Past-Chairman A. G. Bissell made good on his boast of the size of the Puget Sound oysters through the presentation of a

The Colonel Receives Visible Proof That Puget Sound Produces Some Oysters

platter of 12-inch oysters to Colonel Jenks, Senior Vice-President of the Society, and C. A. Loomis, incoming Chairman of the Washington Section.



Some Celebrities at the Speakers Table

The following officers and executive committee were elected for the ensuing year:

Chairman—C. A. Loomis, Bureau of Construction & Repair, Navy Dept.

Vice-Chairman—W. S. Farr, Air Reduction Sales Company.

Secretary—Geo. E. Knox, Bureau of Yards and Docks, Navy Dept.

Treasurer—R. F. Wood, 810—18th St., N. W.

Executive Committee: (Two years) W. F. Dietz, G. A. Ellinger, G. F. Jenks, Harry Huester, W. E. McKenzie, C. M. Underwood. (Term expiring 1940) A. G. Bissell, C. E. Meissner, E. R. Patton, R. B. Swope, E. Whitehead, T. W. Wilson.

WESTERN NEW YORK

The Western New York Section announces the election of the following officers and directors for 1939–1940:

Chairman—J. R. Dawson
Vice-Chairman—W. B. Miller
Secretary—C. S. Freeman
Treasurer—F. O. Howard

Directors for two years—Robert Siemer and Thomas H. Speller

Directors for one year—E. N. Boswell and Randall Schleich.

Mr. Leon C. Bibber, Carnegie Illinois Steel Corp., addressed the May 18th meeting at the Electric Building in Buffalo, on the subject "Welded Joints, Which Ones to Use and When and Why."

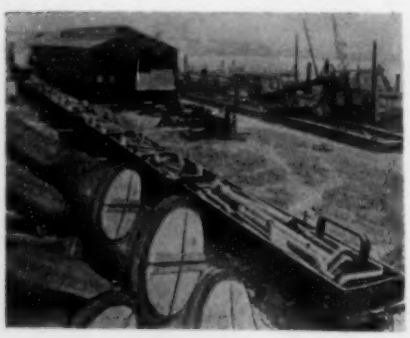
WICHITA

Mr. R. D. Thomas, President, Arcos Corporation, spoke on "Arc Welding Stainless Steel" at the April 28th meeting of the Wichita Section. Mr. Thomas' talk was well received by the 50 members present.

PREFABRICATED PIPING

This is part of a nine-carload order of prefabricated piping, one of the largest shipments of this material ever to leave the Pittsburgh district, produced by Power Piping Division of Blaw-Knox Company for use in a new power plant of one of the major oil companies. A total of 365,000 pounds of pipe, ranging in size from 2 to 30 inches, is involved.

As may be noted from the photograph the extent of welding was a feature of the fabrication. A minimum of fittings were used and the bulk of the valves were welded directly into the line. Flanges at flow meters and at connections to equipment are of the Van-Stone type. All welds and bends on the high-pressure lines were heat treated and stress relieved in specialized equipment possessed by Power Piping. The high-pressure lines will carry steam of 600-pounds pressure at temperatures up to 750° F. Bleeder steam of 150-pounds pressure off the turbines will be used for the processing equipment; and bleeder steam from the process equipment, at 15-pounds pressure, will be used for the heating system.



This part of the shipment moved forward by rail–water–rail.

UNITED STATES STEEL VICE-PRESIDENT

Benjamin F. Fairless, president, announced on April 26, 1939, that G. Cook Kimball had been elected an executive vice-president of the United States Steel Corporation of Delaware with headquarters at its Chicago executive offices now established at 208 South LaSalle Street.

The formal announcement of this new activity was made at a luncheon to meet officers and directors of the corporation. In addition to Mr. Fairless, others who spoke were E. R. Stettinius, Jr., chairman of the board, and E. M. Voorhees, chairman of the finance committee, both of the parent corporation, and Mr. Kimball. Oscar G. Mayer, president, Chicago Association of Commerce, also spoke briefly and praised United States Steel for its decision to establish executive offices in Chicago.

HEAD AND EYE PROTECTION

The Chicago Eye Shield Company, 2300 Warren Blvd., Chicago, has just issued an attractive 48 page book on "Industrial Head and Eye Protection."

This book lists a very wide and complete line of goggles, respirators, spectacles, masks, welding helmets and other safety devices. Besides regular product listings, there is included general information on how non-shattering lenses are

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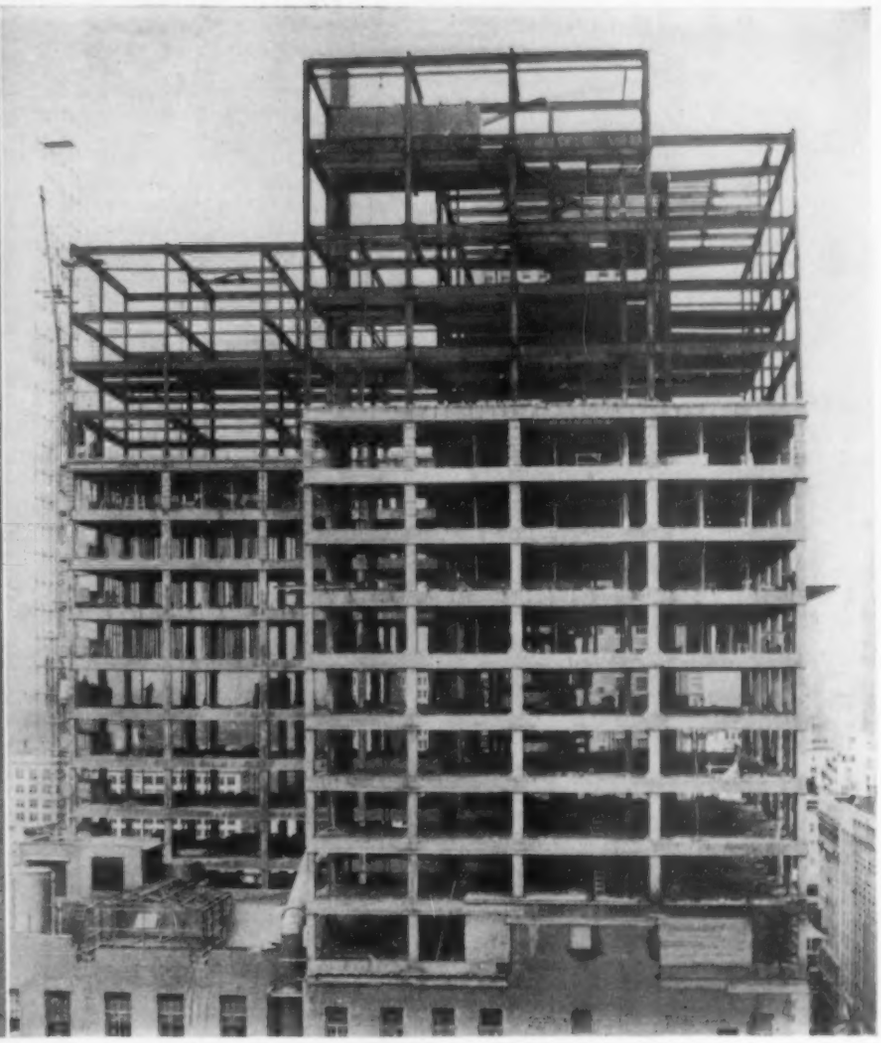
with LINCOLN "FLEETWELD" 100%



BUILDING—13-story addition to Chamber of Commerce Building, Houston, Texas. Existing structure was designed originally to take care of extra load.

CONSTRUCTION—1500 tons of steel. Shop riveted. Field welded for noiseless construction. Columns 14-inch x heaviest weight and reinforced. Girders 21-inch x 68-lb. and 18-inch x 47-lb. Floor beams 12-inch x 32 lb.

WELDING—Approximately 8000 feet of welded joints. Lincoln "Fleetweld" Electrodes used 100%.

PERSONNEL—Consulting Engineer and Designer: Robert J. Cummins; Architect: A. C. Finn; Steel Fabricators: The Mosher Steel Company; Steel Erectors: Peterson Bros.; General Contractors: W. S. Bellows.

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For further information on the welding of structural steel, consult the nearest Lincoln office or mail the coupon.

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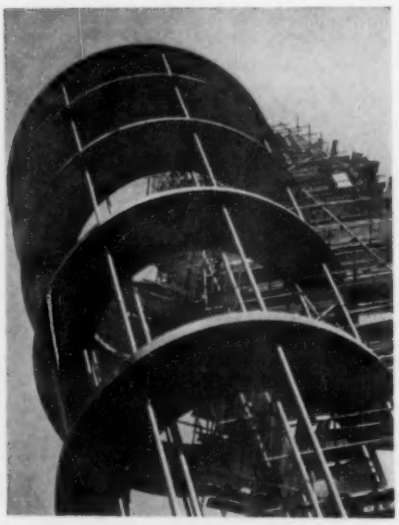
made; what a worker should wear and why, when exposed to ultra-violet and infra-red light rays; and what type of respirator is recommended for over 325 harmful gases, fumes, mists and dusts.

THE SCAIFE FELLOWSHIP AT MELLON INSTITUTE

Wm. B. Scaife & Sons Company of Pittsburgh has established an industrial fellowship in Mellon Institute for the purpose of conducting scientific research on problems pertaining to processes of fabricating and to the use of metal tanks, pressure cylinders and water-softening equipment, its principal products. This investigation work will be in accordance with the company's desire to keep closely informed regarding all technical progress in its own and related fields, with special attention to present and probable future trade requirements, and to effect through research and development all possible improvements in its production practice as well as its products. For many years the company has carried on technical studies in its own organization, but the fellowship will enable the Scaife scientific staff to benefit by the investigational and cooperative facilities of the Institute.

SINGING TOWER



PRE-WELDED SECTIONS and self-closing rivet bolts were typical of the carefully planned engineering that speeded the construction of Westinghouse's 120 foot high Singing Tower of Light designed by Skidmore and Owings, John Moss, Associate as a feature of their New York World's Fair exhibit. The tower has six horizontal rings attached to a triangular steel pylon forming the face of the tower and housing lighting and sound equipment. The lowest tower ring is 18 feet in diameter; the topmost 42 feet. Gravity load is taken by fourteen $3^1/_2$ inch rods but the relatively high wind load is carried by the tower proper. When completed, each evening electronic control will produce a fifteen minute symphony of colored light, water, smoke and fireworks, the effects being synchronized with music.

WELDING IN LOW-COST HOUSING

A fundamental present-day policy of the Federal Government is the encouragement and promotion of the development of adequate housing facilities for the large part of the nation now residing in substandard homes. Since a fundamental part of any industrial development is a thorough research program, the National Bureau of Standards was given the task of investigating the technical aspects of low-cost house construction.

Results of researches on many types of materials and structures used in houses are available to the public in Building Materials and Structures (BMS) Reports. Seventeen reports have been published so far ranging in subject from results of structural tests to data on sound insulation. It is hoped that in the future, on the basis of these tests, house designers and building code officials will depend more upon performance requirements for new houses. The cost of building a house will undoubtedly decrease when new constructions, based on strength required rather than conformity with tradition, are generally accepted.

Since knowledge of the strength of a structure is of highest importance, especially for newer types of constructions, the determination of the structural properties of house elements was included in the research program.

The National Bureau of Standards is cooperating with industry by testing specimens submitted by commercial sponsors without cost to the sponsors. The sponsors must supply specimens which are structural elements of a house and conform to the requirements of Report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.

To date, tests have been made on 22 masonry, 28 wood and 17 steel constructions submitted by 28 sponsors. Seven reports have been issued, one on masonry walls of conventional constructions, and the other six on new types of steel construction. Other reports will be published as the reports are completed.

Welding has been used extensively in the fabrication of the sheet-steel constructions, primarily as a means of fastening the steel components in a quick and permanent manner.

Report BMS9, Structural Properties of the Insulated Steel Construction Company's "Frameless Steel" Constructions for Walls, Partitions, Floors, and Roofs: electric spot welds, made with an automatic machine, fastened the sheet-steel faces to the studs of walls, and fastened overlapping sheet-steel zees and angles to form floors and roofs.

In a cellular sheet-steel floor construction described in Report BMS10, Structural Properties of One of the "Key-stone Beam Steel Floor" Constructions Sponsored by the H. H. Robertson Company, both spot and arc welds were used. The spot welds were made by an automatic machine and tested at frequent intervals. They fastened the sheet-steel formed panels to the flat underside of the floor which formed the ceiling of the room below. The arc welds fastened the panels to the end members of the floor or to the steel framework of the building.

Report BMS11, Structural Properties of the Curren Fabrihome Corporation's "Fabrihome" Constructions for Walls and Partitions, describes a sheet-steel frame construction in which both spot and arc welds are used. The spot welds fastened stiffener angles to the webs of the sheet-steel studs, and fillet welds made by the electric-arc process fastened crossbracing to the studs at mid-height.

Report BMS15, Structural Properties of "Wheeling Long-Span Steel Floor" Construction Sponsored by the Wheeling Corrugating Company, describes a floor construction consisting of sheet-steel channel-shaped joists assembled by welding overlapping upper flanges to form a sheet-steel subfloor to which the finish floor and ceiling were attached. An end member was fastened to the end of the joists by welding. The welds were made by metal arc welding, using direct current.

HERBERT HOOVER TO ADDRESS ENGINEERS

The San Francisco Engineering Council announces that an important feature in the celebration of Engineers' Day on July 13th at the Golden Gate International Exposition is the presence of ex-President Herbert Hoover as the guest of honor. At the morning session on Treasure Island he will discuss the contributions which engineering has made to human welfare, and it is expected that he will also be present at a large gathering of engineers at dinner in the evening.

Engineers' Day is to be celebrated in the midst of a series of national engineering society conventions at San Francisco which will bring thousands of engineers to view the Exposition as well as the Bay Bridges, whose construction ex-President Hoover was instrumental in making possible. The day is to be featured by special demonstrations and displays at the exhibits of the great industrial corporations who are participating in the Exposition, and by the reception which the Exposition authorities will accord to Mr. Hoover.

WELDING ELECTRODES

Just published is a new Becker Brothers Carbon Company, 3450 S. 52nd Avenue, Cicero, Illinois, bulletin giving prices and description of the new and improved BBB Welding Electrodes. In addition to general operation data concerning grip, length of taper, position of shield, etc., the bulletin also illustrates practical solutions to various welding problems such as replacing a gear tooth, replacing or repairing machine parts and so on.

The new BBB Welding Electrodes, as stated by the manufacturer, offer better economy since they are considerably slower burning. Arc control is said to be improved with less "wandering" and, since heat is thus intensified at the point of weld, there is less spread of high temperatures to adjacent areas.